This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at http://books.google.com/

UC-NRLF
B 3 794 984

BERKELEY
LIBRARY
UNIVERSITY OF
CALIFORNIA

EARTH
SCIENCES
LIBRARY

EXCHANGE

EX LIBRIS

GEOLOGICAL SURVEY OF OHIO

EDWARD ORTON, Jr., State Geologist

7-1

FOURTH SERIES, BULLETIN No. 7.

REVISED NOMENCLATURE OF THE OHIO GEOLOGICAL FORMATIONS

BY

CHARLES S. PROSSER, M. Sc.,

Professor of Geology, Ohio State University.

Published by Authority of the Legislature of Ohio, Under the Supervision of the State Geologist.

COLUMBUS, OHIO, NOVEMBER, 1905

EARTH
SCIENCES
LIBRARY

Printed by the Springfield Publishing Company,
Springfield, Ohio.

LETTER OF TRANSMITTAL.

TO HIS EXCELLENCY, MYRON T. HERRICK, GOVERNOR OF OHIO:

SIR:—I have the honor to present you herewith, the seventh bulletin of the fourth series of the publications of the Geological Survey of Ohio. The subject of the bulletin is the Revised Nomenclature of the Ohio Geological Formations, and it is the work of Professor Charles S. Prosser, Professor of Geology in the Ohio State University. This bulletin is a preliminary publication and represents only a portion of the work thus far accomplished by Professor Prosser. In my opinion, his work is of a quality and thoroughness not surpassed by that of any other writer in this field and will at once place this phase of our literature in accord with the most advanced of our neighboring states.

I have the honor to be,

Yours very respectfully,
EDWARD ORTON, JR., E. M.,
State Geologist.

Ohio State University,
November, 1905.

333185

OFFICERS OF THE SURVEY.

EDWARD ORTON, Jr., E. M.,.................................State Geologist

CHARLES SMITH PROSSER, M. Sc..........................Assistant Geologist
Areal and Stratigraphical Geology.

JOHN ADAMS BOWNOCKER, D. Sc........................Assistant Geologist
Economic Geology.

NATHANIEL WRIGHT LORD, E. M.......................Consulting Chemist
Constitution and Utilization of Coals.

METTA L. SEYMOUR.................................Stenographer and Clerk

ANNOUNCEMENT BY THE STATE GEOLOGIST.

BULLETIN VII.

Upon the reorganization of the Survey in 1900, one of the requests made of the Legislature was a modest sum with which to begin a revision of the stratigraphical geology of the State. Although the work accomplished by the previous organizations of the Survey paid more attention to the purely scientific aspects and less to the economic aspects of Ohio geology than is likely to be the case in the present or future surveys, the fact remained that some work on the purely scientific or technically geological side still urgently needed attention, and some work of this sort will always have to be done, if the Geological Survey of Ohio is to hold its position. There is always a tendency upon the part of legislative bodies to limit expenditures for purely scientific work, and to encourage that of a more economic nature, upon which they conceive the return to the State will be greater, or at least more prompt. Nevertheless, the work of pure science as distinct from applied science, is the real basis of progress and no state or government can neglect this branch of geologic work without loss of caste and ultimate loss of efficiency.

Apart from the general right and duty of state geological surveys to do their share of purely scientific research work, there was special need in the case of the Ohio Survey that some revision of the stratigraphical geology should be made. The literature of the Survey was from one to two decades old, and during that time the science of stratigraphical geology had experienced a wide and far-reaching evolution. The formations were divided with much greater minuteness and exactitude, and a new nomenclature had sprung up. The Ohio formations, under their old names and groupings, were no longer in harmony with the ideas of geologists of surrounding states. Either Ohio must revise her work, and bring it up to date or it would be done by others. In fact representatives of the United States Geological Survey, not finding in our literature the facts which they needed for their broader work of correlation, were already being sent into Ohio to supply themselves with the missing facts. The credit of the State in the field of scientific research was thus in danger of being impaired, and this after large expenditures had been made by the earlier geological organizations, whose achievements were of a brilliant order in their time.

Further, there remain certain areas, chiefly in southeastern Ohio, where the statigraphical geology had never been fully unraveled. As this area contains considerable coal, there was also good economic reason for undertaking a study of its geological structure.

In view of this situation, the Legislature met the request of the State Geologist for funds, with the understanding that a portion of the money should be used for this work. Prof. Charles S. Prosser was given charge of this part of the work of the Survey. Prof. Prosser had done a large amount of work in this field of geology in other states, and for the United States Geological Survey, and came to Ohio well equipped to undertake this problem. He has accomplished a large amount of work in this State, and has accumulated much material for a report, but the date at which the latter can be completed is still a considerable distance ahead. In view of this, and the constant need of the new nomenclature in the other reports of the Survey, it was decided that it would be best to bring out the following, as a partial statement and to serve a temporary purpose. Its publication at this time may serve also to bring out the criticism of geologists on contested points, and thus render the final report still more authoritative.

This bulletin was originally prepared for insertion as a chapter in Bulletin IV, but it was finally considered better to publish it in this form, both for the sake of convenience and saving delay. It is hoped that it will serve a very timely and useful purpose until the larger report can be finished.

FORMER PUBLICATIONS OF THE SURVEY.

The work performed by the First, Second and Third organizations of the Geological Survey of Ohio is comprehended in the following list of publications:

FIRST GEOLOGICAL SURVEY 1837-1838

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
First Annual Report........	1838	134	5,000	W. W. Mather
Second Annual Report......	1838	236	5,000	W. W. Mather

SECOND GEOLOGICAL SURVEY 1869-1888.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
Report of Progress.........	1869	176	14,500	J. S. Newberry
Report of Progress.........	1870	568	14,500	J. S. Newberry
Report of Progress.........	1871	3	400	J. S. Newberry
Geology of Ohio, vol. I, part I, Geology...............	1872	680	20,000	J. S. Newberry
Geology of Ohio, vol. I, part II, Paleontology	1873	*401 †49	20,000	J. S. Newberry
Geology, of Ohio, vol. II, part I, Geology..............	1874	701	20,000	J. S. Newberry
Geology of Ohio, vol. II, part II, Paleontology	1875	*431 †59	20,000	J. S. Newberry
Geology of Ohio, vol. III, Geology	1878	958	20,000	J. S. Newberry
Geological Atlas of Ohio....	1879		5,000	J. S. Newberry
Geology of Ohio, vol. IV, Zoology and Botany......	1882	1,070	20,000	J. S. Newberry
Geology of Ohio, vol. V, Economic Geology...........	1884	1,124	10,000	Edward Orton
Preliminary Report on Petroleum and Inflammable Gas	1886	76	2,500	Edward Orton
Geology of Ohio, vol. VI, Economic Geology.......	1888	831	15,000	Edward Orton

*Pages. †Plates.

THIRD GEOLOGICAL SURVEY 1889-1894.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
First Annual Report........	1890	323	10,000	Edward Orton
Geology of Ohio, vol. VII, part I, Economic Geology.	1893	290	2,500	Edward Orton
Geology of Ohio, vol. VII, (complete including part I)	1894	970	7,500	Edward Orton

FOURTH GEOLOGICAL SURVEY 1899——

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
Bulletin 1................	1903	320	8,000	Edward Orton, Jr.
Bulletin 2................	1904	260	6,000	Edward Orton, Jr.
Bulletin 3................	1904	391	4,000	Edward Orton, Jr.
Bulletin 4................	1906	—*	4,000	Edward Orton, Jr.
Bulletin 5................	1906	79	4,000	Edward Orton, Jr.
Bulletin 6................	1906	—*	3,500	Edward Orton, Jr.
Bulletin 7................	1905	36	3,500	Edward Orton, Jr.

*In press.

DISTRIBUTION OF REPORTS.

First Geological Survey.—These volumes are out of print and rare. They can only be procured from dealers in second-hand libraries and are difficult to obtain even there.

Second Geological Survey.—These volumes were all distributed at the time of their issue. The State retained no stock for meeting future demands, so that no copies of any of these volumes can be obtained from the office of the State Geologist. They can be bought in many second-hand book stores, and from dealers in old libraries, at prices ranging from a few cents to two or three dollars per volume, according to rarity and demand. Volumes V and VI are the rarest and most sought for.

Third Geological Survey.—These volumes were all distributed at the time of issue, except Vol. VII, of which 1,500 were put in the hands of the Secretary of State, for sale at the cost of publication. Of these, a few remain at the date of the publication of this volume. The price is $1.50. To obtain copies, send postal or money order to the Secretary of State, State House, Columbus, Ohio. No other volumes can be obtained from this source.

The other volumes of this series can be procured only from second-hand book and library dealers.

Fourth Geological Survey.—Under the law, copies of these Bulletins can be bought at the office of the State Geologist at the cost of publication. Postal orders, money orders, checks, drafts, or currency must accompany orders. Stamps will not be received.

Bulletin 1—Oil and Gas	$ 0.65
Bulletin 2—Uses of Hydraulic Cements	0.30
Bulletin 3—Manufacture of Hydraulic Cements	0.50
Bulletin 4—Lime Resources and Lime Industries	In preparation
Bulletin 5—Lime-Sand Brick Industry	In preparation
Bulletin 6—Bibliography of the Geology of Ohio, and Index to Publications of the Geological Survey of Ohio	———
Bulletin 7—Revised Nomenclature of the Ohio Geological publications	———

LAWS UNDER WHICH THE SURVEY OPERATES.

For the information of the public, the law under which the work of the Survey is prosecuted is herewith published:

Laws of Ohio, 1889, Vol. 86, p. 262.

(Senate Bill 409.)

AN ACT

To provide for the extension of the Geological Survey of the State.

Section 1. Be it enacted by the General Assembly of the State of Ohio, That the governor is hereby authorized to appoint a state geologist, whose duty it shall be to continue and extend the investigations already made into the geological structure and resources of the state. Said state geologist shall be appointed for a term of three years, but he may be removed for cause at any time, and a successor appointed in his stead; and the governor is authorized to fill any vacancy which may occur from any cause, at any time. The compensation of said state geologist shall be at the rate of two hundred dollars per month, for the time actually employed; and said geologist shall have power to employ such assistants as he may need; but in no event shall the salary of the geologist, pay to assistants, and expense of the department, exceed the amount of the expenditure authorized by the general assembly.

Section 2. It shall be the duty of said geologist to study, and determine as nearly as possible, the number and extent of the various formations of the state; to represent the same, from time to time, upon properly constructed maps and diagrams; to study the modes of occurrence and the distribution of the useful minerals and products of these formations; to determine the chemical composition and structure of the same; to investigate the soils and water supply of the state; and to give attention to the discoveries of coal, building stone, natural cement, petroleum, gas and other natural substances of use and value to the state. He may also collect and describe the fossils of the various geological formations of the state; but no expenditure shall be incurred under this head that is not expressly ordered and provided for by the general assembly.

Section 3. The said geologist shall make, on or before the first day in February of each year. a report to the governor, covering the work of the preceding year, and the report shall be transmitted to the general assembly, to be printed in the same manner as other public documents, or as shall be otherwise ordered.

Section 4. The salaries of the state geologist, and the assistants employed by him, together with the traveling and incidental expenses, shall be paid monthly, on presentation of properly itemized vouchers, signed by the governor out of the state treasury, from the appropriation made for such purpose.

Section 5. There is hereby appropriated from the general revenue fund the sum of one thousand dollars annually, for the purpose above named.

Section 6. This act shall take effect and be in force from and after its passage.

NOAH H. ALBAUGH,
Speaker pro tem. of the House of Representatives.
THEODORE F. DAVIS,
President pro tem. of the Senate.

Passed April 12, 1889.

From the terms of the law, it was evidently intended to provide for the creation of a bureau of geology to which only a portion of the time of the State Geologist should be applied, as the annual appropriation made was much too small to provide the salary of a State Geologist continuously, without making any provisions for office expenses, assistance, etc. It was thought at that time that a few months' work per year would be sufficient to maintain the Survey abreast of geological developments.

The powers and duties of the State Geologist under this act were made so broad and general as to permit carrying on almost any work, so that no new legal provision was thought necessary in connection with re-opening the work of the Survey under the Fourth organization. The sum designated in Section 5 is not made a limiting condition of the law so that the Legislature may appropriate any other amount, at its discretion, for carrying on the work.

Acting under this law, the Legislature has made the following appropriations for geological work:

Designation of Legislature.	Year.	Amount Appropriated.
Seventy-Fourth..............	1900	$2,500 00
Seventy-Fourth..............	1901	$3,500 00
Seventy-Fifth................	1902	$5,000 00
Seventy-Fifth................	1903	$3,000 00
Seventy-Sixth................	1904	$2,800 00
Seventy-Sixth................	1905	$2,900 00

The law providing for the publication and distribution of reports is as follows:

Laws of Ohio, 1902, Vol. 95, p. 593.

(House Bill, 800).

AN ACT

To Provide for the Publication and Distribution of the Reports of the State Geologist.

Section 1. Be it enacted by the General Assembly of the state of Ohio, That whenever the state geologist shall have completed a bulletin upon any of the subjects upon which he is authorized to conduct investigation, he shall notify the state printing commission of this fact, and it shall be the duty of this commission to determine the number of copies which shall be printed, and the grade of paper, the kind of binding, and any other details incident to its proper publication.

Section 2. It shall be the duty of said commission to provide for the publication of said bulletin as soon as possible after the completion of the same. The issue shall consist of a minimum number of three thousand copies.

Of these, one thousand copies, after deducting 200 for the State Library, shall be distributed pro rata among the general assembly.

One thousand shall be distributed free by the state geologist in exchange with other surveys, and with individuals whose services have been used in the collection or preparation of the matter for the bulletins. Of this number not more than four hundred may be distributed during the first year after publication, and not more than fifty in any subsequent year.

One thousand copies shall be set aside for binding along with other bulletins from time to time, when a sufficient number of such bulletins have accumulated to make collectively a volume of from 800 to 1,000 pages. They shall be bound, lettered and numbered, to take their place in the series of volumes already published by the survey.

The distribution of the bound volume of the survey shall be in the hands of the state geologist; but the state library shall receive ten copies, each member of the general assembly one copy, with privilege to draw not to exceed two other copies on application, and public libraries in the state shall be supplied with one copy each. The volumes remaining after these demands have been met, may be distributed among the geological surveys and geological societies of the United States and of foreign countries in exchange for their publications.

Section 3. The board may, at its discretion, order the publication of extra copies in addition to the three thousand already provided for. These extra copies shall be placed in the hands of the state geologist. From these members of the general assembly may, on application, draw up to fifty (50) copies each. Those remaining shall be placed on sale at a price equal to the net cost of printing and binding, which price is to be established by the state supervisor of public printing. The proceeds of such sales shall be accounted for and paid into the state treasury, and the state geologist shall be required by the commission to give suitable bond for the security of the funds thus passing through his hands. The proceeds of such sales shall be credited to the account of the geological survey and shall be used for the prosecution of the further work of the survey without distinction from other funds which the general assembly from time to time appropriates for the survey.

Section 4. The cost of printing, illustrating, electrotyping, binding, et cetera, of said bulletins and said volumes, shall be paid from the general appropriation for state printing.

Section 5. This act shall take effect from and after its passage.

W. S. McKINNON,
Speaker of the House of Representatives.
F. B. ARCHER,
President of the Senate.

Passed May 12, 1902.

THE SURVEY IN ITS RELATIONS TO THE PUBLIC.

The usefulness of the Survey is not limited to the preparation of formal reports on important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the State. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the people demanding such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1st. Requests for information covered by previous publications.—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the enquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2d. Requests for identification of minerals and fossils.—This is done, where possible. As a rule, the minerals and fossils are simple and familiar forms, which can be answered at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3d. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station, to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the Survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the Survey is on this point. Requests for State aid in determining the value of private mineral resources, ranging from an assay worth a dollar, up to drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the Survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a State chemist or State geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the Survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for State examaintion. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses, and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the Survey, but it is nevertheless of very direct benefit to the people of the State.

REVISED NOMENCLATURE OF THE OHIO GEOLOGICAL FORMATIONS.[1]

By CHARLES S. PROSSER.

INTRODUCTION.

The great advance in stratigraphical geology during the last fifteen years together with the more precise and accurate description of geological formations will lead, in most states, to a revision of the geological scale. The effect of this advance in the science was shown in New York, the classic state in American geology, when six years ago Dr. J. M. Clarke and Prof. Charles Schuchert published a revised classification of the geological formations of that state.[2] Most of the changes proposed by these distinguished authors have been accepted by working geologists and are now becoming a part of American geology. At about the same time the writer began an investigation of the Ohio formations, but the work has not yet reached the desired completeness and accuracy and, as will be seen by reference to the geological scale, in the case of certain formations a definite classification cannot be proposed until the information is more complete.

The advance in our knowledge of the stratigraphical geology of the state together with the introduction of a considerable number of new names for different formations and the approaching publication of reports by the Ohio Geological Survey led the State Geologist, Prof. Edward Orton Jr., to request a revision of the Geological Scale of the state for these reports. In compliance with the above request the following scale has been prepared, which in its preliminary form is now submitted for discussion. The writer will be pleased if geologists familiar with the Ohio formations will communicate to him their opinions in regard to this classification or any part of it. Such communications will be retained, duly considered and credited in an extended discussion of this subject which the writer has in preparation.

---

[1] This chapter is a revision and elaboration of an article published by the author in the *Journal of Geology*, October, 1903, Vol. XI, pp. 519–547.

[2] *Science, N. S.*, Vol. X, Dec., 15, 1899, pp. 874–878. The article was reprinted in the *Am. Geologist*, Vol. XXV, Feb., 1900, pp. 114–120, and in July, 1903, the "Classification of New York Series of Geologic Formations," by Dr. John M. Clarke, was published as Handbook 19 of the New York State Museum.

GEOLOGICAL SCALE OF OHIO.

System.	No.	Formation.	Thickness.
Quaternary.	26	Alluvium. Glacial Lake beds. (1) Wisconsin drift....................Chamberlin '95 Peorian soil......................Leverett '98 Silt or Iowan drift (?).............Chamberlin '95 Sangamon soil....................Leverett '98 Illinoian drift.....................Leverett '97	(2) 0–550′
(3) Permian (?).	25	Dunkard formation (4.)...........I. C. White '91 (Upper Barren Coal-measures).	525′±
Carboniferous.	24	Waynesburg coal, No. 11. (?) (5) Monongahela formation...........H. D. Rogers '40 (Upper Productive Coal-measures). Pittsburg coal, No. 8	200–250′
	23	Conemaugh formation (6) .... F. Platt '75 (Lower Barren Coal-measures).	400–500′
	22	Upper Freeport coal, No. 7. Allegheny formation.............H. D. Rogers '40 (Lower Productive Coal-measures). (7).	165-300′
	21	Pottsville formation, (8) Lesley '77. { .... (9) Sharon conglomerate, (10) I. C. White, '79 (?)	250′±
	20	Maxville limestone (11).............Andrews '70	25′±
	19	Logan formation (12)..............Andrews '70	100-150′
	18	Black Hand formation (13)............ Hicks '78	50-500′
	17	Cuyahoga formation (14)..........Newberry '70	150-500′
	16	Sunbury shale (15) ....Hicks '78	5-30′
	15	Berea grit.......................Newberry '70	5-175′
- - (17) - -	14	Bedford shale (16)................Newberry '70	50-150′

GEOLOGICAL SCALE OF OHIO—Concluded.

System.	No.	Formation.	Thickness.
Devonian.	13	Southern and Central Ohio. Ohio shale (18) Andrews '70 Northern Ohio. Cleveland shale, Newberry '70 Chagrin formation (19) Prosser '03. Huron shale (20) Newberry '70	300-2600′
	12	Olentangy shale.............N. H. Winchell '74	20-35′
	11	Delaware limestone (21)...............Orton '78	30-40′
	10	Columbus limestone (22)..........Newberry '73	110′
Upper Silurian.	9	Monroe formation (23) Lane '93 Northwestern Ohio. The formation is composed of the three following members in this part of the state: Lucas limestone (24) Prosser '03 Sylvania sandstone Orton '88 Tymochtee member (?) N. H. Winchell '73	50-600′
	8	Northern Ohio. "Niagara group" (25) Vanuxem '42. Southern Ohio. Hillsboro sandstone(26)Orton '71 Cedarville limestone...Orton '71 Springfield limestone..Orton '71 West Union limestone Orton '71 Osgood beds, (27)... Foerste '97 Dayton limestone.	150-350′
	7	Clinton limestone (28) ....Vanuxem '42	10-50′
	6	Northern Ohio. Medina shale (?) the 3 (29) Vanuxem '42. Southern Ohio. Belfast bed (30) Foerste '96	Wells 50-150′ Belfast 5′
– (31) – – –	5	Saluda bed (33) .... Foerste '02	20′±
Lower Silurian. (32)	4	Richmond formation (34)......N. H. Winchell and E. O. Ulrich '97	300′±
	3	Lorraine formation (35)..............Emmons '42	300′
	2	Eden shale (36)......................Orton '73	250′
	1	Trenton limestone (37)..............Vanuxem '40	130′

The general equivalence of the formations shown in the preceding table to those listed by Dr. Orton in Volume VII of the Geological Survey of Ohio, is shown in the following table:

GEOLOGICAL SCALE OF OHIO.

Orton, 1895.	Prosser, 1905.
Glacial drift.	Alluvium and Glacial.
Upper Barren Coal Measures.	Dunkard formation.
Upper Productive Coal Measures.	Monongahela formation.
Lower Barren Coal Measures.	Conemaugh formation.
Lower Productive Coal Measures.	Allegheny formation.
Conglomerate Group.	Pottsville formation.
Sub-carboniferous limestone.	Maxville limestone.
Logan Group.	Logan formation. Black Hand formation.
Cuyahoga shale.	Cuyahoga formation.
Berea shale.	Sunbury shale.
Berea grit.	Berea grit.
Bedford shale.	Bedford shale.
Ohio shale. { Cleveland shale. Erie shale. Huron shale.	Ohio shale { Cleveland shale. Chagrin formation. Huron shale.
Olentangy shale.	Olentangy shale.
Upper Helderberg or Corniferous limestone.	Delaware limestone. Columbus limestone.
Lower Helderberg limestone, or Waterlime.	Monroe formation. { Lucas limestone. Sylvania sandstone. Tymochtee member(?).
Niagara Group. { Hillsboro sandstone. Guelph or Cedarville limestone. Niagara limestone. Niagara shale.	"Niagara group." { Hillsboro sandstone. Cedarville limestone. Springfield limestone. West Union limestone. Osgood beds.
Clinton limestone.	Clinton limestone. Belfast bed.
Medina shale.	Saluda bed.
Hudson River Group.	Richmond formation. Lorraine formation. Eden shale.
Utica shale, not seen in outcrop.	
Trenton limestone.	Trenton limestone.

NOTES ON THE GEOLOGICAL SCALE OF OHIO.

1. The glacial formations of Ohio have recently been very fully described by Mr. Frank Leverett, to which account the readers interested in these deposits are referred.[1]

2. The thickness assigned to the various formations is frequently that given in the last volumes of the Geological Survey of Ohio, or other late reports of Dr. Orton. Changes have been made in stating the thickness of certain formations, based upon data secured by the writer, or upon trustworthy statements of other authors. The thickness, however, of most of the formations differs so greatly in different sections that it is almost impossible to make general statements which will apply throughout the state. This variation is often indicated by giving the thickness as ranging *from* and *to* a certain number; as for example the glacial drift is given as from 0 to 550 feet in thickness. In a few instances the thickness has been obtained from well records, as for the Medina shales (?) of northwestern Ohio and the maximum thickness of the Ohio shale.

3. In 1880 Professors Wm. M. Fontaine and I. C. White described the flora of the Upper Barren Coal-measures of West Virginia and southwestern Pennsylvania and stated that "To sum up finally the evidence derived from all sources, we find ourselves irresistibly impelled to the conclusion, that the . . . . . Upper Barrens of the Appalachian Coal Fields are of Permian age."[2]

The fauna of those rocks is very small and does not afford conclusive evidence as to their age, but the flora has recently been re-examined by Dr. David White who corroborates the earlier conclusions of Fontaine and I. C. White. Dr. David White states that "Recent collecting materially increases the Permian evidence, and seems to leave little room for doubt that the beds in and above the Washington limestone are referable to the Lower Rothliegende of western Europe. The data so far obtained from the lower beds of the Dunkard are, in the judgment of the writer, not yet conclusive as to Permian age."[3]

In a later and fuller account of this examination before the Geological Society of America, Dr. White reported that "On account of the small number of species which may be considered as in a measure characteristic of the Rothliegende, the absence from the latter of Callipteris, the old world Dyassic Odontopteris and Callipteridium, and the extreme rarity of the types of later facies, it appears that the beds below the Lower Washington limestone cannot yet be regarded as conclusively referable to the Rothliegende, though they contain a flora which is certainly transitional. The re-enforcement of this flora at the levels of the Washington and Dunkard coals by the more important and distinctly characteristic Rothliegende species mentioned above, seems to fully justify the reference of the latter to the Rothliegende, the lower boundary of which may probably be safely drawn as low as the Washington limestone, which is as yet the lowest observed Callipteris horizon. Further search in the floras of the lower beds of the Dunkard and in the Monongahela is necessary before the upper boundary of the Coal-measures can be definitely ascertained. The flora of the upper portion of the Dunkard is to be compared with those of the Stockheim and Cusel beds in Germany and of the series in the basin of Brives in France........

---

[1] U. S. Geol. Surv., *Monograph* XLI, 1902.
[2] Second Geol. Surv. Pa., PP., p. 119.
[3] *Science, N. S.*, Vol. XVII, Feb. 20, 1903, p. 298.

"Our highest Appalachian Paleozoic beds do not appear, so far as yet studied paleobotanically, to extend above the Lower Rothliegende of western Europe. The Zechstein, if originally present, as seems not unlikely, has long since disappeared. The reference of the greater part of the Dunkard to the Lower Rothliegende appears to be well founded; but it seems to the writer as probable that the plants of the Upper Dunkard or of the lowest of the terranes of western Europe that are now generally classed as Rothliegende are hardly of so late a date as the flora of the Artinsk stage of Russia."[1]

The Rothliegende is the older division of the Permian of western Europe, which is found typically in Germany. The Artinsk stage in Russia is referred by the eminent Russian geologist Dr. Tschernyschew to the Permo-Carboniferous; but by Dr. Frech and many other European geologists it is considered as lower Permian.

The lower Washington limestone occurs in the lower part of the Dunkard formation and at the typical locality at Washington , in southwestern Pennsylvania, 117 feet above the top of the Waynesburg coal or base of the Dunkard formation.

A number of European geologists have accepted Permian as the age of the Dunkard formation, and Dr. Frech states that the Dunkard Creek beds and Cassville plant shale, the latter of which is the shale at the base of the Dunkard formation immediately overlying the Waynesburg coal, are the equivalent of the Cusel stage, which is the oldest division of the Lower Rothliegende of Germany. And in another sentence is the statement that the petrographical and paleontological similarity of the Dunkard with the Rothliegende of western Europe is therefore beyond doubt.[2] Dr. Kayser also puts the Dunkard in the Permian and he has made the following statement concerning its age: In the United States we find in the East (Virginia, Pennsylvania, etc.) in conformable layers upon the upper Carboniferous the so-called Barren Measures with *Callipteris conferta, Taeniopteris* and other Permian characteristic forms together with typical Carboniferous plants as representative of the Permian.[3]

Recently Dr. I. C. White has reviewed the evidence relating to the correlation of the Dunkard formation and reaffirmed his former opinion of its Permian age.[1] He even considers that there is evidence "confirmatory of the Permo-Carboniferous age of the main portion of the Conemaugh series."[2]

---

[1] Bull. Geol. Soc. Amer., Vol. 14, March, 1904, pp. 541, 542.
[2] Lethaea geognostica, Th. I, Lethaea palaeozoica, Bd. 2, Lief, 3, 1901, p. 546.
[3] Lehrbuch d. Geol. Formationskunde, Second ed., 1902, p. 264.

4. This formation was named the Dunkard Creek series on account of the fine exposures found for thirty miles along the banks and bluffs of this stream, which flows along the West Virginia-Pennsylvania line.[3]

Later, with Dr. White's sanction, the name was shortened to the Dunkard formation, thus bringing it in harmony with the terms now usually selected for the names of formations.[4]

On the scale, below the accepted name for this formation, is given in parenthesis "Upper Barren Coal-measures," the name which has generally been used for this formation in the Ohio reports. The corresponding name which has been used in the Ohio reports for the three succeeding formations is given in the same manner.

5. The top of the Waynesburg coal, or its horizon, and the base of the Pittsburg coal mark the top and bottom of the Monongahela formation.

Dr. Stevenson correlated Coal No. 11, of the Ohio coals, with the Waynesburg coal of southwestern Pennsylvania,[5] which on account of "its sudden variations in thickness," he stated, "is commonly known in western Belmont Co., Ohio, as the 'jumping six-foot seam.'"[6] This correlation was also accepted by Dr. Newberry.[7]

6. Franklin Platt applied the name Conemaugh to the "Middle Barren Measures" and "Mahoning sandstone" in his "Column of Palæozoic formations" but failed to define it more precisely.[8]

Later the name was defined and used for this formation in Maryland[9] and its boundaries fixed with precision. The formation includes all the rocks between the *base* of the Pittsburg coal and the *top* of the Upper Freeport coal.

On the Huntington Folio, West Virginia-Ohio, of the Geologic Atlas of the United States, Mr. Campbell has referred between 200 and 300 feet of conglomeratic rocks, succeeding the Kanawha black flint, to the Charleston sandstone,[10] which was named by Campbell and Mendenhall in 1896, from exposures near Charleston, West Virginia.[11] The age of this sandstone is in question. According to the views of Dr. I. C. White, it probably represents about the lower third of the Conemaugh formation. Dr. White's correlation is as follows: "The name Charleston sandstone was given to these beds [the Mahoning sandstone, which forms the lower part of the Conemaugh formation in Pennsylvania], and the overlying Buffalo sandstone, by the U. S. G. Survey in its Charleston Folio, but as the name Mahoning, given by the First Geological Survey of Pennsylvania, from the Mahoning river in that state, has priority, the new one cannot be adopted without violating one of the fundamental laws of nomenclature."[1] On the other hand, Dr. David White and Mr. Campbell consider that the greater part or all of the Charleston sandstone belongs in the upper part of the Allegheny formation. Dr. David White says: "It appears that the upper boundary of the representatives of the Allegheny series lies some distance, probably over 200 feet, above the Black Flint."[2] The Kanawha black flint, which outcrops to the east of Charleston, West Virginia, marks the base of the Charleston sandstone, but it is not clear from Mr. Campbell's description whether he includes it in the Kanawha formation or the Charleston sandstone.[3] Dr. Stevenson, however, states that "The 'Kanawha black flint' is the highest bed of the Kanawha formation."[4] Dr. David White also identified a small flora from near Clay, West Virginia, which he stated "may be from terranes, not later than the Freeport group,"[5] and finally Mr. Campbell in his paper on the "Variation and equivalence of the Charleston sandstone," has published diagrams showing that the horizon of this flora, which is marked B on the figures, occurs about 300 feet above the Kanawha flint, or essentially at the top of the Charleston sandstone at its typical locality.[6]

---

[1] *West Virginia Geol. Surv.*, Vol. II., 1903, pp. 119-124.

[2] *Ibid.*, p. 256.

[3] Bull. *U. S. Geol. Surv.*, No. 65, pp. 19-20.

[4] O'Harra: *Maryland Geol. Surv.*, Allegany County, 1900, pp. 86-128, and Prosser: *Jour. Goclogy* Vol. IX, 1901, p. 428.

[5] *Annals Lyceum Nat. Hist. N. Y.*, Vol. X, 1873, pp. 230-231 (Reprint pp. 7-8); Rept. *Geol. Surv. Ohio*, Vol. II, Part I, 1874, p. 158; and *ibid.*, Vol. III, Part I, 1878, pp. 262-264.

[6] *An. Lyc. Nat. Hist. N. Y.*, Vol. X, p. 231 (Reprint p. 8) and essentially the same statement is made in Rept. *Geol. Surv. Ohio*, Vol. III, Part I, p. 264.

[7] *Ibid.*, Vol. II, Part I, pp. 161-163.

[8] *Second Geol. Surv.* of Pa., H., p. 8.

[9] O'Harra: *Maryland Geol. Surv.* Allegany County, 1900, pp. 86-118, and Prosser: *Jour. Geology*, Vol. IX, 1901, p. 426.

[10] *Folio No.* 69, p. 4 and sheets.

[11] Seventeenth Ann. Rept. *U. S. Geol. Surv.*, Part II , p. 508.

The 800 feet of shales and sandstones succeeding the Charleston sandstone of the Huntington quadrangle are correlated with the Braxton formation by Mr. Campbell and represented as covering all that portion of southern Lawrence county, Ohio, to the east of Ironton, which is represented on this quadrangle. This formation was named in 1896 by Taff and Brooks, from exposures in Braxton county in central West Virginia.[7] According to the opinion of Dr. I. C. White, this formation, as described in this Folio, probably represents about the upper two-thirds of the Conemaugh and the lower part of the Monongahela formation. Following the correlation, however, of Dr. David White and Mr. Campbell, its base corresponds essentially to that of the Conemaugh formation and it is uncertain whether it extends upward into the Monongehala formation or not.

7. Doctors Orton and I. C. White practically agreed in tracing the the Lower Productive Coal-measures or Allegheny formation from the Ohio–Pennsylvania state line across the state to the Ohio river.[8]

---

[1] W. Va., Geol. Survey, Vol. II, 1903, p. 307.

[2] Bull. Geol. Soc. Amer., Vol. 11, 1900, p. 178.

[3] In the Charleston Folio it is apparently included in the Kanawha formation under the description of that formation (p. 5, col. 1); but on the "Columnar Section Sheet" it is given as apparently forming the base of the Charleston sandstone.

[4] Bull. Geol. Soc. Amer., Vol. 15, 1904, p. 164.

[5] *Loc. cit.*, p. 173.

[6] *Jour. Geol.*, Vol. XI, 1903, p. 462 and see statement on p. 467.

[7] Geologic Atlas of the United States, Buckhannon folio, No. 34, p. 2 and sheets.

[8] Orton; Rept. Geol. Surv. Ohio, Vol. V., pp. 1–128, and Vol. VII, pp. 276–282; I. C. White: Bull. U. S. Geol. Surv., No. 65, pp. 130–136, and West Virginia Geol. Surv., Vol. II, pp. 339–341, 379, 380, 493, 500–506.

On the Huntington Folio, Mr. Campbell used the name Kanawha formation for the rocks below the Charleston sandstone, which occur on the southern part of the sheet[1]. This formation was described by Campbell and Mendenhall in 1896[2]; but the name was apparently preoccupied, for in 1877 Franklin Platt in his classification of the rocks that would be penetrated by a well ten miles in depth near Waynesburg, in southwestern Pennsylvania, proposed the name "Kenawha [as he spelled it] river system," from the river of that name in West Virginia, division *b* of which he called the "Kenawha Coal Measures."[3] The Pottsville conglomerate formed the upper part of the Kenawha river system and the Mountain limestone its base, so that the limits of the division differ considerably from those of the Kanawha formation of Campbell and Mendenhall. In case it is held that Platt did not define this division with accuracy, and that the Kanawha formation of Campbell and Mendenhall ought to be accepted by prescription, then it is to be remembered that the name "Kanawha black flint" was definitely applied by Dr. I. C. White to a subdivision of the Barren Measures, or Elk River series in 1891.[4]

Regarding the correlation of the Kanawha and Allegheny formations it may be said that Dr. David White has studied the flora of the Kanawha formation in its typical region and claims that the lower portion is older than the Allegheny formation[5]; while the flora of its upper part is "probably not higher than the Clarion group in the Allegheny series."[6]

The horizon of the Upper Freeport coal, the top of the Allegheny formation, is indicated as between 200 and 300 feet above the Kanawha black flint.[7]

This paper has been very positively answered by Dr. I. C. White, who says: "During the present year [1901] I have attacked the problem in question by direct tracing of the Upper Freeport coal and its associated strata from the Pennsylvania line along their eastern outcrops across to the Kanawha valley. In this I was entirely successful, and the result is a complete confirmation of my original conclusion with reference to the horizon of the Upper Freeport coal on the Great Kanawha, namely, that it is the first one below the black-flint stratum, and hence this latter member belongs near the *base of the Conemaugh formation,* or just above the *top* of the Allegheny, where my studies in 1884 first placed it, instead of near the *base of the Allegheny,* to which position Dr. David White has assigned it, on the basis of fossil plants."[8]

Dr. I. C. White also states in this paper that in the red shale belt of the Conemaugh formation "occurs an important fossiliferous limestone horizon, the 'green crinoidal limestone' of the Pennsylvania series, which has been traced from central West Virginia northward to the Pennsylvania line and through southwestern Pennsylvania into Ohio [where it is known as the Ames limestone] and across that state without a break to where it re-enters West Virginia again at Huntington."[1]

---

[1] Folio 69, 1900, p. 4, col. 3 and sheets.
[2] Seventeenth Ann. Rept. U. S. Geol. Survey, Pt. II, p. 499.
[3] Second Geol. Surv. Pa., H^2, pp. XXIV-XXVII.
[4] Bull. U. S. Geol. Surv., No. 65, p. 98.
[5] Bull. Geol. Soc. Amer., Vol. 11, 1900, pp. 165–167.
[6] *Ibid.*, p. 170.
[7] *Ibid.*, pp. 173–178.
[8] *Ibid.*, Vol. 13, 1902, p. 122.

And finally he states that " the Pittsburg coal is found in the summits of the hills only two miles north from Charleston," West Virginia.[2]

Later Dr. David White is reported to have said that "The further study of the floras indicates not merely that the middle of the formation [Kanawha] may be of Mercer age, but that beds up to within 125 feet of the 'Black Flint' are clearly referable to the latter group, while the basal Allegheny time boundary is probably very much nearer the level of the Black Flint."[3] And finally he has reported that "The Mercer group and Connoquenessing sandstones [two members of the Pottsville formation] appear to represent by far the greater part of the Kanawha formation in southern West Virginia."[4]

Dr. I. C. White, in his Coal Report of West Virginia, has discussed at length the correlation of the Coal-measure formations of southern West Virginia and especially the line of division between the Allegheny and Conemaugh formations. In general, he firmly adhered to his former interpretation[5]; but in the closing part of the report he is not so positive and states that Dr. David White's view, "while improbable from general considerations, is not impossible."[6]

This report was followed by Mr. Campbell's paper on the "Variation and equivalence of the Charleston sandstone," in which he claimed that it "is not equivalent to the Mahoning sandstone of Pennsylvania."[7] Near the close of the paper is the statement that "If the writer has observed correctly (and the facts seem to be beyond question), it is possible for Dr. [I. C.] White to trace sandstone in outcrop from the well-known Mahoning of Pennsylvania, to the Charleston of the Kanawha valley, but that does not necessarily mean that they are of the same age."[8]

Finally, Dr. Stevenson, in his memoir on the "Carboniferous of the Appalachian Basin," critically considered the formations of the Kanawha valley and, in the main, apparently accepted the correlation of David White. He said, "The Stockton coal bed [which is the first one below the Kanawha black flint, and was correlated by Dr. I. C. White with the Upper Freeport coal] is at the horizon of Kentucky coal 6, which is the Lower Kittanning, being at only a few feet above the Ferriferous limestone. Doctor White's sections, north from the Kanawha, show conclusively that the Stockton cannot be higher than the Kittaning horizon, so that it is in the lower portion of the Allegheny formation."[1]

---

[1] *Ibid.*, p. 123.

[2] *Ibid.*, p. 124

[3] Mendenhall's Report of the 144th meeting of the Geological Society of Washington, *Science, N. S.*, Vol. XVII, June 12, 1903, p. 942.

[4] Bull. Geol. Soc. Amer., Vol. 15, June 1904, p. 281, f. n. *

[5] West Virginia Geol. Surv., Vol. II, July, 1903, pp. 325-328, 333–336, 500–506.

[6] *Ibid.*, p. 604 and see in this connection pp. 593–608.

[7] *Jour. Geol.*, Vol. XI, September 1903, p. 461 and see the "Diagramatic Setion of the Charleston-Mahoning Sandstone," Fig. 1, on p. 462

[8] *Ibid.*, p. 468.

For an explanation of the adoption of Dunkard, Monongahela, Conemaugh and Allegheny as formation names in Ohio, see a former paper by the present writer.[2]

Dr. I. C. White prefers to consider these terranes as series and writes me as follows: "I think the term series better describes the different divisions of the Carboniferous system, like Dunkard, Monongahela, Conemaugh, Allegheny, Pottsville, etc., and have so used it in my coal volume."[3] Dr. David White also apparently prefers to regard these terranes as having the rank of series.[4]

8. So far as the writer is aware the name Pottsville conglomerate did not first appear over the name of Professor Lesley, but on its first publication, in 1877, it is distinctly stated by both Ashburner[5] and Franklin Platt[6] that it is "proposed by the present State Geologist of Pennsylvania," and the following year Professor Stevenson mentioned Professor Lesley's name in crediting the authorship of the formation.[7] In the Ohio reports this formation has generally been termed theConglomerate group, although Dr. I. C. White, as early as 1881, applied the name Pottsville conglomerate to the continuation of these rocks across the state line in Crawford county, Pennsylvania. Certain geologists, however, have thought that these rocks of Ohio and western Pennsylvania represented a longer time interval than the typical Pottsville conglomerate of eastern Pennsylvania, and, hence, it has appeared doubtful whether the name Pottsville should be applied to the Ohio formation. At its base in northern Ohio is a conglomerate, or coarse grained sandstone, which has generally been called the Sharon conglomerate, and is perhaps equivalent to the Olean conglomerate of southwestern New York. Regarding the stratigraphic position of this latter conglomerate, Dr. J. M. Clarke has written me as follows: "It may interest you to know with regard to the Carboniferous horizons that . . . . . . Messrs. David White and Campbell have been over the field in Cattaraugus county and they have convinced themselves that there is no longer any question of the Pottsville age of the Olean. This determination seems to be based largely on the evidence of fossil plants."[8]

This conclusion agrees with the statement of Mr. M. R. Campbell, apparently based upon the investigations of Dr. David White, regarding the age of the Sharon conglomerate of western Pennsylvania. Mr. Campbell says: "From the evidence afforded by fossil plants, Mr. White proves conclusively that about the beginning of the Pottsville epoch an uplift occured, which affected much of the Mississippi Valley. A large land area was formed that extended as far east as the Broad Top basin and the Northern Anthracite field. This land area persisted until at least 600 feet of Pottsville sediments were deposited in the Southern Anthracite basin. A subsidence then occurred in the western part of the state, which allowed the Sharon conglomerate and its associated coal group to be deposited."[1]

---

[1] Bull. Geol. Soc. Amer., Vol. 15, May, 1904 p. 209.

[2] *Am. Jour. Sci*, 4th ser., Vol. XI (1901), pp. 191–200 and in particular p. 199.

[3] Letter of April 2, 1903.

[4] See Bull. Geol. Soc. Amer., Vol. 6, p. 305 and *ibid.*, Vol. 11, p. 145, where in the titles of the two papers the term series follows the terrane names of Pottsville, Kanawha and Allegheny.

[5] Proc. Amer. Phil. Soc., Vol. XVI, p. 533.

[6] Second Geol. Surv. Pa., H^2, p. XXVI.

[7] *Ibid.*, K^3, 1878, p. 12.

[8] Letter of April 30, 1903.

Finally, Dr. Stevenson regards the correlation of the Sharon conglomerate or sandstone and the Olean conglomerate as proven.[2]

Pottsville sandstone is used by Mr. Campbell as the name of the formation in the Masontown–Uniontown Folio, in southwestern Pennsylvania, and it now appears that there is sufficient evidence to warrant the application of the term Pottsville to the Ohio formation, as has been done by the U. S. Geological Survey.[3]

9. In the later reports of the Ohio Survey, the following main divisions of the "Conglomerate group" were given as succeeding the Sharon conglomerate in the following order: Sharon coal, Lower and Upper Massillon sandstones, Lower and Upper Mercer groups and Homewood sandstone, the last one named forming its upper part.[4] While in Pennsylvania, in Crawford county, along the Ohio line, Dr. I. C. White gave the Pottsville as composed in ascending order of the following divisions: Sharon, Connoquenessing, Mercer group and Homewood sandstone. The Sharon division consisted in ascending order of a Conglomerate, Lower shales, Coal and Upper iron shales and the Connoquenessing division of the Lower and Upper sandstones separated by the Quakertown beds.[5] Dr. Stevenson considers that the Massillon and Connoquenessing sandstones are equivalent, and states that the "Lower Connoquenessing, ... is apparently the original Massillon of Newberry, though afterwards that term was applied to both divisions."[6] The name "Massillon sandstone" apparently first appeared in Dr. Newberry's "Section of the Lower Coal Measures of Ohio," published in 1874[7], and was rather imperfectly described in his "Report on the Geology of Stark County," published in 1878.[8] The name Connoquenessing sandstone was published by Professor Lesley in 1880[9], and both divisions described by Dr. I. C. White in 1881.[10]

Finally, in the Charleston, West Virginia, Folio, which is the next quadrangle east of the Huntington one, Mr. Campbell has used the name Sewell formation for at least part of the rocks of the Pottsville age shown in that area[11]; but it is not known how much of the "Conglomerate group" of Ohio is included in this formation. It was named in 1896 by Campbell and Mendenhall, from the outcrops near Sewell on the New river in southern West Virginia.[1]

---

[1] Geologic Atlas U. S., Masontown–Uniontown Folio, No. 82, 1902, p. 7.
[2] Bull. Geol. Soc Amer., Vol. 15. 1904, pp. 55, 56, 58, 69, 206.
[3] Twenty-second Ann. Rept., Part III, 1902, pl. XII.
[4] Rept. Geol. Surv. Ohio, Vol. VII, 1893, [1895], p. 36.
[5] Second Geol. Surv. Pa., Q^4, 1881, p. 55 and following ones.
[6] Bull. Geol. Soc. Amer., Vol. 15, 1904, p. 78 Also see pp. 77, 82 and 205.
[7] Rept. Geol. Surv. Ohio. Vol. II, Part I, p. 131.
[8] *Ibid.*, Vol. III, Part I, p. 166 and see "Section of the Rocks of Stark County" on p. 155.
[9] Second Geol. Surv. Pa., H^5, p. VIII and see pp. 325, 326.
[10] *Ibid.*, Q^4, pp. 55–58.
[11] Geologic Atlas of the United States, Folio 72 1901 p. 4 and sheets.

In northern and central Ohio it appears probable that the Pottsville formation will be divided into at least two members. The lower one is the conglomerate or coarse sandstone, generally termed the Sharon conglomerate, which is a conspicuous lithologic division. At present we are not prepared to propose a classification for the remaining part of the formation.

10. In the later reports of the Ohio Survey, this division is usually called the Sharon conglomerate. Professor Lesley used the name *"Sharon Conglomerate* (Ohio Conglomerate)" in the list of geological divisions for Lawrence county, Pennsylvania,[2] and on page xxxiv, he states that the Sharon conglomerate "is undoubtedly part (or the whole) of the *Ohio Conglomerate."* Also on page 296 is a brief description by Dr. I. C. White, of the Sharon conglomerate as exposed near the town of that name. Of the two names used by Professor Lesley, Ohio was preoccupied as Andrews used it in 1870 for the Ohio shale; and it is a question whether Sharon was available, since Professor H. D. Rogers, in 1858, proposed the name "Sharon group" for the Sharon coal and associated rocks overlying this conglomerate, but apparently *not* including it,[3] and in 1877 Dr. Stevenson followed Rogers in describing the Sharon coal group of western Pennsylvania.[4] Professor Lesley also used the name Sharon conglomerate for the lower subdivision of "The Conglomerate" in his classification of that formation published in 1880.[5] On the same page it was stated that this division "has been extended eastward through Venango and Warren counties by Mr. Carll, who, however, calls the Sharon Conglomerate by its local name in his district, the *Garland Conglomerate,"* and still farther east by Mr. Ashburner who used the name "*Olean Conglomerate* for the Sharon or Garland." On the "Geological Map of Mercer county. [Pa.]," by I. C. White, dated 1879, it is stated in the "Explanation of Colors" that one represents the "Area of the Sharon (Ohio, Olean) Conglomerate."[6]

The "Olean conglomerate" was formally named and described by Ashburner, in 1880, in his description of the geology of McKean county.[7]

The above statement is corroborated by Professor Lesley, for he has stated that "the Olean conglomerate received its name during the survey of McKean county, from the magnificent fragment of it at the rock city north of the state line, west of the town of Olean [N. Y.]."[8]

The above, however, was not the first usage of the name Olean for this conglomerate, for Professor Lesley, himself, in 1875 used the term

---

[1] Seventeenth Ann. Rept. U. S. Geol. Surv. Part II, p. 494.
[2] Second Geol. Surv. Pa., Q^2, 1879 (?), Preface, p. XXIX.
[3] Geol. Pa.. Vol. II p. 489.
[4] Second Geol. Surv. Pa., K^2. p. 103.
[5] *Ibid.*, H^5, p. VIII.
[6] *Ibid.*, Q^3. 1880, and for description of the Sharon conglomerate see pp. 56–59.
[7] *Ibid.*, R, p. 56 and see "General Vertical Section of the Rocks of McKean County" on p. 43.
[8] *Ibid.*, A. Sum. Desc. of the Geol. of Pa., Vol. III. Part I, 1895, p. 1873.

"Olean conglomerate (Garland)" in referring to this member in northwestern Pennsylvania.[1]

Later, in the same report, Mr. Carll used the name "Garland conglomerate" for the rocks capping the hills in the vicinity of Garland, Warren county, Pennsylvania (p. 45). I cannot say positively that the names Olean and Garland conglomerate made their initial appearance in geological literature in the above quoted instances. In 1875, however, under the direction of Mr. Carll a spirit level line was run accross northwestern Pennsylvania "for the purpose of connectedly tracing the several *outcrops of Garland conglomerate,* that they might thus be identified with cotemporaneous rocks in the state of New York on the one side and in the state of Ohio on the other."[2]

As a result of this work Mr. Carll stated that the Garland conglomerate "is apparently identical with the *Olean* conglomerate in McKean county; with the *Sharon conglomerate* in Mercer county; [and] with the *Ohio conglomerate* in Ohio,"[3] and the chapter is headed "The Garland (Olean or Sharon) Conglomerate."[4]

In Carll's succeeding report he abandoned the use of Garland conglomerate in favor of Olean conglomerate and in explanation said: "In Report I, I^2, I^3 I have used the term *Garland conglomerate.* It is now demonstrated that my *Garland conglomerate* is the *Olean conglomerate* of Mr. Ashburner's report on McKean county, and I shall therefore use the latter term in this report."[5]

Professor H. S. Williams apparently considered the Sharon conglomerate in the Cuyahoga and Painesville sections as equivalent to the Olean conglomerate, for in those sections it is lettered H and in the paper is the statement that "H is the conglomerate (Olean and equivalent.)"[6] In later papers in a section representing the geological formations of Licking county, in central Ohio, Professor Williams has mistaken the Logan conglomerate of Dr. Orton, one of the formations of the Waverly series, now known as the Black Hand, for the Sharon conglomerate and on a "Comparative Chart of Devonian Sections" represented it as the equivalent of the Garland and Olean conglomerates.[7] In Licking county, Ohio, to the southeast of Newark, the base of the Sharon conglomerate may be found about 115 feet above the top of the Black Hand formation. Professor Williams stated that "The thickness from the top of the Devonian limestone to the base of the Logan group [Black Hand formation] in central Ohio is 675 feet."[8]

---

[1] *Ibid.*, I, p. 38, f. n.

[2] *Ibid.*, I^3, 1880, p. 11.

[3] *Ibid.*, p. 13.

[4] *Ibid.*, p. 11.

[5] *Ibid.*, I^4, 1883, p. 185, f. n.

[6] Proc. A. A. A. S., Vol. XXXIV, 1886, p. 225; and see plate of "Meridional Sections of the Upper Devonian Deposits of New York, Pennsylvania, and Ohio."

[7] Bull. Geol. Soc. Amer., Vol. 14, 1903, pl. 16 and see p. 180, and U. S. Geo,. Surv, Bull No. 210, 1903 pl. 1 and see p. 121.

[8] Bull. Geol. Soc. Amer., Vol. 14, p. 180.

The Newark[1] and Homer[2] well records, of Licking county, which is the county cited by Professor Williams for central Ohio[3], checked in part by surface exposures show that the thickness of the formations from the top of the Devonian limestone to the base of the Black Hand formation range from 1,350 to 1,450 feet. While from the base of the Black Hand formation, which Professor Williams supposed to represent the Garland and Olean conglomerates of northwestern Pennsylvania and southwestern New York, to the base of the Sharon conglomerate on the hills southeast of Newark is an additional 215 feet[4], making the thickness of the section in central Ohio, which he compared with equivalent eastern sections in Pennsylvania and New York, from 1,565 to 1,665 feet instead of 675 feet. Finally, the next section to the eastward on Professor Williams' chart, which is described as at "Meadville, Crawford county, Pennsylvania, and across Erie county, Pennsylvania,"[5] shows the Shenango sandstone at its top and represents it as the equivalent of the Garland and Olean conglomerates of the sections farther to the east. In its typical region on the Pennsylvania–Ohio border the Shenango is the *first sandstone below* the Sharon or Garland conglomerate from which it is separated by from 35 to 50 feet of rock composed of flaggy sandstone and shale and known as the Shenango shale.[6] This shale is regarded by Dr. Stevenson as the thinned western representative of the Mauch Chunk red shale of Maryland and southeastern Pennsylvania and he uses this name for the upper formation of the Mississippian series in the Appalachian basin, instead of Mauch Chunk.[7]

Finally, on the "Geologic Map of New York" by Frederick J. H. Merrill, published in 1901 [1902], the Olean conglomerate appears as the name of this Carboniferous formation in southwestern New York. Regarding the identity of these two conglomerates Dr. J. M. Clarke has written me as follows: "I have recently come into possession of an elaborate compilation of all the well sections in the region of McDonald, Pennsylvania, prepared by Mr. F. H. Oliphant, wherein the Sharon conglomerate is made identical with the Olean."[8]

Dr. I. C. White would retain the name Sharon for this conglomerate and has written me to this effect. He says: "I do not think the use of 'Sharon' for the *conglomerate* of that name is forbidden, because it had previously been given to a *coal* bed, since the things are so unlike. . . . . . . I think 'Sharon' conglomerate, which applies only to a particular bed of the 'Pottsville' series, should stand, and not be replaced by 'Olean,' since the term 'Sharon' is older as applied to the stratum in question."[9]

---

[1] Dr. Orton: Rept. Geol. Surv. Ohio, Vol. VI, 1888, p. 371.

[2] Prof. Bownocker: Geol. Surv. Ohio, Fourth Series, Bull. No. 1, 1904, p. 120.

[3] *Loc. cit.*, p. 179 and pl. 16.

[4] Am. Geol., Vol. XXXIV, 1904, pp. 359, 360.

[5] Bull. Geol. Soc. Amer., Vol 14, pl. 16, Section B, and U. S. Geol. Surv., Bull. No. 210, pl. 1 Section B.

[6] See Second Geol. Surv. Pa., Q^3, 1880, pp. 59–61 and *ibid.*, Q^4, 1881, pp. 77–83.

[7] Bull. Geol. Soc. Amer., Vol. 14, pp. 85, 95, and 96.

[8] Letter of March 23, 1903.

[9] Letter of April 2, 1903.

Regarding the age of the Olean and the question of its correlation with the Sharon conglomerate, Dr. David White has written as follows: "The Olean is shown to be Pottsville. It contains sufficient upper Carboniferous plants to prove it to be Pennsylvanian; but not enough to strictly define its age beyond upper Pottsville. . . . .

"The correlation of Sharon and Olean is a working assumption based in part on circumstantial evidence, both formations being found in the same relation, beneath the thin sections of Pottsville, on the eroded lower Carboniferous. I have no conclusive proof that they are equal and represent the same formation. And, since over part of the way between Sharon and Olean the Connoquenessing seems to rest directly on the Pocono, I personally favor the use of Sharon, in conformity with Dr. I. C. White's usage, until satisfactory proof of the identity of Olean and Sharon may be established."[1]

Therefore, since there is yet some doubt regarding the identity of the Olean and Sharon conglomerates, the latter name is retained for the present for this member of the Pottsville formation in Ohio.

11. From a study of the fossils of the Maxville limestone, Professor Meek was led to correlate it with the Chester limestone, the upper formation of the Subcarboniferous or Mississippian series of the Mississippi valley. He said, "I can scarcely doubt that we have in these local masses of limestone a representation of the Chester group of the Lower Carboniferous limestone series; though it is possible that there may also be some representation of the St. Louis limestone [the formation next older than the Chester] of the same series at some of the outcrops."[2] In general the above correlation was corroborated by Professor R. P. Whitfield, who later published an article with the title of "Species from the Maxville limestone, the equivalent of the St. Louis and Chester limestones of the Mississippi valley."[3] Recently Dr. Stuart Weller has studied a collection of fossils from the northern extension of the Greenbrier limestone in Fayette county, Pennsylvania, and stated that the fauna is "essentially identical with that of the Maxville limestone in Ohio." Furthermore he stated that the Maxville and Fayette county faunas "are of Genevieve age—a name which is used to include both the St. Louis and Chester or Kaskaskia of earlier authors. From the relationships of the faunas in the east it is not easy to determine to what portion of the Genevieve epoch the fauna belongs. The fauna of the Batesville sandstone in Arkansas, however, is closely related to these and it lies at the base of the Kaskaskia, just above the St. Louis, and it will probably be safe to assume that the age of the Pennsylvania and West Virginia faunas is about mid-Genevieve."[4] In this article by Dr. Stevenson, he calls attention to the fact that the name Maxville limestone is older than Greenbrier limestone. Dr.

---

[1] Letter of June 10, 1903.

[2] Rept. Geol. Surv. Ohio, Vol. II, Part I, 1874, p. 101. Also see *ibid*, Vol. I, Part I, 1873, p. 315.

[3] *Ibid.*, Vol. VII, 1895, p. 465.

[4] Am. Geol., Vol. XXIX, 1902, pp. 247, 248.

Stevenson wrote as follows: "It is unfortunate that the name Maxville, applied to the limestone in Ohio, by E. B. Andrews in 1869, has been overlooked. . . . . The adoption of this name [in place of Greenbrier limestone] would be not only a recognition of the law of priority, but it would be also a just recognition of a faithful geologist, whose work, for the time, was of high order."[1] The following year Dr. Stevenson used Maxville as the name of one of the four formations which he recognized as composing the Lower Carboniferous or Mississippian series of the Appalachian basin,[2] and correlated with it the "greater part of upper Newman and of upper Greenbrier in Virginia."[3]

Beneath the Maxville limestone, about two miles east of Rushville, Professor Andrews found about 27 feet of sandstone, shale and limestone before reaching the top of his Logan sandstone, to which he gave provisionally the name "Rushville group."[4] As yet too little is known concerning this division to warrant an opinion regarding its stratigraphic rank.

12. The name Logan formation is retained for that division, or its equivalent, which Professor Andrews in 1870 named the Logan sandstone from outcrops in Hocking county, near Logan[5], which was stated to overlie the Waverly conglomerate at Black Hand on the Licking river east of Newark and to extend down that valley "to a point between Pleasant Valley and Dillons Falls."[6] In 1888 Dr. Orton united the Waverly conglomerate and Logan sandstone of Andrews to form the Logan group.[7] If it be advisable to make one formation of these two divisions, the above name is inappropriate, because the Logan sandstone of Professor Andrews clearly referred to the upper division *only*, as has been noted by Professor Herrick.[8]

13. Black Hand is the name given by Professor Hicks in 1878 to the deposits of coarse sandstone and conglomerate exposed at Black Hand, in the gorge of the Licking river and about Hanover.[9] This division was named the Waverly conglomerate by Professor Andrews in 1870;[10] but Waverly was preoccupied, because Professor C. Briggs Jr., in 1838, proposed the name "Waverly sandstone series" for the rocks occurring between the "argillaceous slaty rock, or shale stratum," now known as the Ohio shale, and the "Conglomerate" which lies at the base of the Coal-measures, as exposed in the southern counties of the state to the east of the Scioto river.[11] Later Professor Andrews defined the "Waverly sandstone" as "A group of sandstones and shales, measuring on the Ohio river

---

[1] *Ibid.*, pp. 243, 244.

[2] Bull. Geol. Soc. Amer., Vol. 14, March, 1903, p. 96 and see pp. 93–95.

[3] *Ibid.*, p. 85. The "lower Newman and Greenbrier in Virginia; lower of Greenbrier in Maryland" were correlated with the Tuscumbia, the next older formation.

[4] *Am. Jour. Sci. and Arts*, 3d ser., Vol. XVIII, 1879, p. 137.

[5] Geol. Surv. Ohio, Part II, pp. 76–79.

[6] *Ibid.*, p. 79.

[7] Rept. Geol. Surv., Ohio, Vol. VI, p. 39.

[8] Bull. Geol. Soc. Amer., Vol. 2, 1891, p. 38.

[9] *Am. Jour. Sci.* and *Arts*, 3d ser., Vol. XVI, 1878, pp. 216–217.

[10] Geol. Surv. Ohio, Part II, p. 135, and on the explanation of the "Section on Hocking River" of the "Map Showing the Lower Coal Measures."

[11] First Ann. Rept. Geol. Surv. Ohio, p. 80.

640 feet" and extending from the "Ohio Black Slate" to the base of the Subcarboniferous limestone in the Kentucky hills (now known as the Maxville limestone),[1] which are the present limits of the Waverly series. Professor Andrews also correlated the conglomerate at Black Hand with that of the Waverly and gave its thickness at that locality as probably 50 or 60 feet.[2]

14. Possibly later studies may decide that for eastern Ohio it will be better to drop the name Cuyahoga formation and use the classification of western Pennsylvania for the rocks between the top of the Berea grit and the base of the Olean conglomerate, which in ascending order are Orangeville shale, Sharpsville sandstone, Meadville shales, Shenango sandstone, and Shenango shales, all named and described by Dr. I. C. White in 1880,[3] with the exception of the Meadville shales, which was published in 1881,[4] and in the latter report he united the Shenango sandstone and Shenango shale to form the Shenango group.[5]

Professor H. P. Cushing, however, writes me as follows regarding this matter: "I do not believe that the Pennsylvania subdivisions can be made out west of Ashtabula and Trumbull, or even that they are well marked on the highland west of the Grand river, in those counties. Here in Cuyahoga the shales between the Berea and the conglomerate show only a two-fold lithological division, to the best of my knowledge, and the boundary occurs about half way up. The lower half consists of soft, blue-black clay shales with a few local flags, especially towards the base. On top of these comes a flaggy horizon, at what I take to be the Sharpsville level, followed by alternating shales and concretionary layers, with some flags . . . . The basal shales are sparingly fossiliferous, a big *Orbiculoidca* most abundant, and impressing a layman as being a Sunbury fauna in depauperate condition. The flags and following shales hold a numerous fauna, pyritized and badly preserved in the flags, excellently preserved in the concretions, which form definite bands."[6]

Dr. Orton, in 1874, in his description of Pike county, in southern Ohio, stated that the next division above the "Waverly black slate" (now called the Sunbury shale), "has for its chief characteristic the well-known and very valuable quarries of the Waverly system that lie along the Ohio River below Portsmouth. This subdivision has a definite base, viz., the upper surface of the Waverly black slate; but there is no characteristic stratum that constitutes a convenient superior limit. As the most valuable of the building rock, however, that is furnished by this part of the series in southern Ohio occurs within fifty feet of the slate, these fifty feet next above the slate may be somewhat arbitrarily taken as a subdivision. It may be designated as the Buena Vista section—the name being derived from a locality on the Ohio river that furnishes a large amount of stone of unequaled quality."[1] The writer has revived this name, defined the upper limit and used it for the lower member of the Cuyahoga formation in southern and central Ohio.[2]

---

[1] Geol. Surv. Ohio, Part II, 1870, p. 65.
[2] *Ibid.*, p. 79.
[3] Second Geol. Surv. Pa., Q^3, pp. 59-63.
[4] *Ibid.*, Q^4, pp. 83-85.
[5] *Ibid.*, pp. 77-83.
[6] Letter of April 2, 1903.

Again in southern Ohio in the Ohio river section below and above Portsmouth succeeding the top of the Sunbury shale, which is a very conspicuously marked horizon, it is a matter of some difficulty to divide the remaining Waverly rocks into the formations which are so clearly marked lithologically in central Ohio.

15. This shale was first recognized by Professor E. B. Andrews, in 1870, from outcrops in the Ohio valley in Adams and Scioto counties and named the Waverly black slate.[3] The name Waverly, however, was preoccupied at that time, since the "Waverly sandstone series" was published by Professor C. Briggs Jr., in 1838.[4] In 1875 Meek in the explanation of a figure of *Discina* (*Orbiculoidea*) *Newberryi* Hall gave the occurrence of the specimen as in the "Berea shale,"[5] which is apparently the first usage of this name in a stratigraphic sense, although it is not probable that Meek intended to recognize the shale as a stratigraphic unit. This interpretation is supported by the fact that under the description of this species Meek gave its geological position as "the Cuyahoga shale."[6] In September, 1878, Professor Hicks named it the Sunbury shale from exposures about two miles east of that town,[7] which is the first geographic term applied to this shale which can be retained as a formation name. In August of the following year Dr. Orton stated that "no better name could be found for it than Berea shale"[8] and this name was used for the formation in the succeeding reports of the Geological Survey of Ohio. Berea, however, as a formation name was preoccupied when used by Meek in 1875 or Orton in 1879, since it was used for the Berea grit by Newberry in 1870.[9]

16. The formations from Nos. 14 to 19, inclusive, form the Waverly series. For a revision of the classification of this series in central Ohio, see a paper by Prosser, in *Jour. Geology*, Vol. IX, 1901, pp. 205–232; for an extended discussion of the Sunbury shale, see *ibid.*, Vol. X, 1902, pp. 262–313, and for a further description of these formations in central Ohio see *Am. Geologist*, Vol. XXXIV, 1904, pp. 335–361.

Bedford shale was named by Newberry in 1870[10] from the outcrops at Bedford, southeast of Cleveland, and fully described by him in 1873.[11] The term "Bedford rock" appears in Richard Owen's description of the geology of Lawrence county, Indiana, published in 1862;[12] but it was not used as the name of a geological division and was not described. The next occurrence of "Bedford stone" is in the Indiana report published in 1874, which it will be noticed is one year later than Dr. Newberry's full description of the Bedford shale of Ohio, in which Professor John Collett described the "Geology of Lawrence county" and under the geological division of the St. Louis limestone, which was composed of beds Nos. 24–17, inclusive, he stated that "bed No. 22 is the quarry bed which furnishes in unlimited supply the famous 'Bedford stone' so favorably known."[1]

---

[1] Rept. Geol. Surv. Ohio, Vol. II, Part I, p. 626.

[2] *Am. Geol.*, Vol. XXXIV, 1904, pp. 341, 342. footnote.

[3] Geol. Surv. Ohio, Rept. Progress in 1869 [1870], Part II, p. 66.

[4] First Ann. Rept. Geol. Surv. Ohio, p. 80.

[5] Rept. Geol. Surv. Ohio, Vol. II, Part II, Palæontology, Plate XIV, explanation Fig. 1d.

[6] *Ibid.*, p. 278.

[7] *Am. Jour. Sci.*, 3d ser., Vol. XVI, p 216.

[8] *Ibid.*, Vol. XVIII, p. 138.

[9] Geol. Surv. Ohio, Rept. Progress in 1869, p. 21. For a complete historical review of the different opinions regarding the age of the Sunbury shale see the *Jour. Geol.*, Vol. X, 1902, pp. 263–272.

[10] Geol. Surv. Ohio, Part I, Rept. Progress in 1869, p. 21.

[11] Rept. Geol. Surv. Ohio, Vol. I, Part I, pp. 188–189.

[12] Rept. Geol. Reconnoissance of Indiana during 1859 and 1860, p. 137.

It is evident, however, on reading the report, that Professor Collett did not use the term "Bedford stone" as the name of a geologic unit. It was, however, excellently described in 1896 by Hopkins and Siebenthal under the formation name of the "Bedford oölitic limestone."[2] Finally, in 1901 Professor Edgar R. Cumings, of Indiana University, wrote as follows: "Since the term Bedford as the name of a formation is preoccupied, having been applied to the 'Bedford shale' of northeastern Ohio in 1870, the writer proposes the name *Salem limestone* for the rocks called Bedford limestone by Hopkins and Siebenthal."[3] It is the writer's opinion concerning the formational names of "Bedford shale" and "Bedford oölitic limestone" that the former is the one entitled to stand and this opinion is sustained by the Committee on Geologic Names of the United States Geological Survey. The writer submitted the question to this committee and the following decision was communicated by the Director, Hon. Charles D. Walcott: "(1) That Bedford rock was used by Owen in 1862 in a *Report of Geological Reconnaissance of Indiana*, 1859–60, p. 137, but the usage is so indefinite as not to constitute a pre-emption of the term for stratigraphic purposes. (2) Bedford shale is a term first employed by Newberry in *Ohio Geological Survey Report of Progress*, 1869, p. 21 and this usage should stand. Furthermore, it is understood here that Mr. Cumings has recently proposed to drop the name of Bedford limestone of Indiana, and substitute for it Salem limestone."[4] Both sides of this question were fully presented in the *Journal of Geolgy*, in 1901, by Siebenthal, Cumings, Prosser and Chamberlin.[5]

17. The line of division between the Carboniferous and Devonian systems is in doubt as indicated by the dotted line on the chart. In recent years it has generally been drawn at the base of the Bedford shale, but Professor C. L. Herrick has indicated the line as high as the lower part of the Black Hand formation or perhaps even higher.[6] Dr. I. C. White writes me as follows concerning this point: "The *red Bedford shale* is undoubtedly of Catskill age, as is also the Berea sandstone and its overlying shale (I think) since it becomes *red* in passing eastward. If you

---

[1] Fifth Ann. Rept. Geol. Surv. Ind., made during the year 1873–4, p. 276.

[2] Twenty-first Ann. Rept. Ind., Dept. Geol. and Nat. Res., pp. 291–298. Also see their account in the Eighthteenth Ann. Rept. U. S. Geol. Surv., 1897, Part V (continued), p. 1050.

[3] *Jour. Geol.*, Vol. IX, pp. 232–233.

[4] *Jour. Geol.*, Vol. X, 1902, p. 277, f. n.

[5] Vol. IX, pp. 215, 232–236, 267–272.

[6] Bull. Den. Univ., Vol. IV, 1888, pp. 100–106.

mean to class the Catskill as *Carboniferous* then your division is correctly drawn, but if you think the Catskill is Devonian, then the Carboniferous line should be drawn at the base of the Cuyahoga. I am non-committal on the general question as to whether we should include the Catskill in the Carboniferous or not, but the *red Bedford* and the overlying Berea with its shale above (red at the east) are certainly of Catskill age."[1]

18. David Dale Owen in giving a summary of the geology of Indiana after stating that the soft freestone knobs of that state were equivalent to the Waverly rock of Ohio, said: "The black slate in the base of these knobs is the equivalent of the Scioto slates and shales."[2]

In the above reference Dr. Owen undoubtedly referred to the shales which were later named the Ohio by Andrews[3]; but it is thought that this casual use of the term "Scioto slates and shales" ought not to replace the definite one of Andrews, which is now a well known name in geological literature.

In 1877 Professor Shaler, evidently unaware that Professor Andrews had named the black shale of southern Ohio the Ohio black slate, proposed as a new name for this formation Ohio shale.[4]

In northern Ohio, equivalent to the Ohio shale of southern and central Ohio, are three formations, the lower and upper ones composed mainly of black shale and called the Huron and Cleveland shales, separated by a mass of grayish shales and thin sandstones now called the Chagrin formation.

19. This formation was named the Erie shale by Newberry in 1870,[5] but it was preoccupied. Vanuxem in 1842 named one of the divisions of the New York system, the Erie, which was composed of the formations ranging from the Marcellus shale to the Chemung inclusive[6]; while Logan in 1863 named one of the Quaternary formations of Ontario the Erie clay.[7]

Finally, the name Girard shale, applied by Dr. I. C. White in 1881 to a mass of Devonian shales in Erie county, in northwestern Pennsylvania,[8] is only equivalent to a portion of Newberry's Erie shale.

The name Chagrin formation[9] was, therefore, proposed for this mass of argillaceous and arenaceous shales and calcareous layers on account of the excellent exposures on the banks of this river extending from Willoughby to the south of Pleasant Valley. With perhaps the exception of the cliffs on the shore of Lake Erie there are probably no finer outcrops of the formation to be found than those forming the steep banks of the Chagrin river. One and one half-miles south of Willoughby is a cliff nearly a hundred feet high and a magnificent one more than a hundred feet high occurs a mile below Pleasant Valley, about four miles up the river southeast of Willoughby.

---

[1] Letter of April 2, 1903.

[2] Cont. Geol. Rec. of the State of Indiana, 1838, Part II, 1859, p. 59.

[3] Geol. Surv. Ohio, Part II, 1870, p. 62.

[4] Geol. Surv.Ky., Rept. Prog., Vol. III, N. S., p. 169.

[5] Geol. Surv. Ohio, Part I, Rept. Prog., 1869, p. 20.

[6] Geol. N. Y., Part III, p. 13.

[7] Geol. Surv. Canada. Rept. Prog., from Com. to 1863, pp. 896–897.

[8] Second Geol. Surv. Pa., Q^4, pp. 117–118.

[9] *Jour. Geol.*, Vol. XI, 1903, pp. 521, 533.

20. The term "Huron shale" was proposed by Dr. Newberry in 1870 for the "great mass of black, bituminous shale, designated by the former Geological Board as the 'Black Slate.' "[1]

Its outcrop was described as forming "a belt from ten to twenty miles in width, reaching from the Lake shore [Erie] at the mouth of the Huron river, almost directly south to the mouth of the Scioto." Its outcrop on the shore of Lake Erie was given as extending from east of Sandusky to Avon Point. The higher black shale outcropping near Cleveland was named the Cleveland shale, which was separated from the lower black shale or Huron by the Erie shale. It is now generally supposed that Newberry's Huron shale in northern Ohio, although represented on the "Preliminary Geological Map of Ohio" accompanying the 1869 report, as extending across the state from Lake Erie to the Ohio river, and in the southern part apparently comprising all of the black shale which Andrews, later in the same report, named the Ohio black slate, represents only the lower mass of black shale which occurs in the northern part of the state. It was not until much later than the above report that it was known that the top of the Ohio shale in southern Ohio corresponds with the top of the Cleveland shale and that Andrews' Ohio shale is equivalent to the Huron, Erie and Cleveland shales of Dr. Newberry in northern Ohio. Later Dr. Newberry has stated that "I have called this, in Ohio, the Huron shale, because it forms for a long distance the banks of the Huron River, and as it represents several distinct strata in New York and Pennsylvania, it could not with propriety take the name of either of them."[2]

In 1861 Prof. Alexander Winchell gave the name "Huron group" to a division of the Michigan rocks which included all the deposits between the top of his Hamilton group and the base of a conglomerate overlying the Pt. aux Barques gritstones.[3]

This comprised a much greater stratigraphic range than the Huron shales of Newberry, since on the Ohio scale it represents approximately all the rocks from the base of the Huron shales nearly to the top of the Cuyahoga and perhaps into the Black Hand formation.[4]

Newberry, however, in his first description of the Huron shales, did not refer to the Huron group of Winchell, although together they had examined the rocks about Cleveland[5]; but in a later report he stated that in Michigan they form "the lower part of Professor Winchell's *Huron Croup.*" And he furthermore said, that the two members of Winchell's Huron group "having nothing in common either in lithological characters or fossils, we have in Ohio separated them; giving the name *Erie* shale to the upper portion, retaining the name of Huron for the lower."[1] This plan, however, does not appear to have been a happy solution of the question and it was, therefore, submitted to the Committee on Geologic Names of the U. S. Geological Survey and the Chairman, Mr. Bailey Willis, has sent me the following communication: "*Huron group or Huron shale* was brought before the Committee through a letter from Professor Prosser, of May 28, 1903, the question being whether a formation—the *Huron shale*—may bear the same name as a group to which it belongs; it was the sense of the Committee that such use of terms in duplication was contrary to the regulations of the Geological Survey, and that as the group had been named in 1861 and the shale not until 1869 [1870], the term *Huron* should be applied to the *group*."[2]

---

[1] Geol. Surv. Ohio, Part I, Rept. Prog., 1869, p. 18
[2] Mon. U. S. Geol. Surv., Vol. XVI, 1889, pp. 57-58.
[3] First Bien. Rept. Prog. Geol. Surv. Mich., 1861, pp. 71, 139.
[4] See Lane: Geol. Surv. Mich., Vol. VII, Part II, 1900, pl. I.
[5] First Bien. Rept. Prog. Geol. Surv. Mich., 1861, p. 78.

In 1893 A. C. Lane named the shales forming the lower part of Winchell's Huron group the St. Clair, which were included between the Traverse group and the Richmondville or Berea sandstone of the Michigan formations.[3] Dr. Lane has written me that, "I do not now think that [the Richmondville] is the Berea, but a stray sandstone somewhat higher up."[4]

In the Ohio formations the "St.Clair shale" represents approximately the rocks from the top of the Olentangy shale to the base of the Berea grit and therefore is neither synonymous with Newberry's Huron shale, nor with Andrews' Ohio shale, since the equivalent of the Bedford is included in the St. Clair shale. The name "St. Clair," however, was preoccupied when used by Dr. Lane, because Dr. Penrose Jr., in 1891 gave it to a Silurian limestone in northern Arkansas,[5] and therefore Lane has renamed the St. Clair the "Antrim shales."[6]

In 1874 Mr. Wm. W. Borden named the black shale in southern Indiana the "New Albany black slate;"[7] but it is considered that this represents more nearly the thinned westward extension of the Ohio shale after crossing Kentucky, than Newberry's Huron shale. Outcrops of the New Albany shale have been described by Dr. Kindle in the Wabash river region of northern Indiana to the westward of Logansport.[8]

It does not appear to the writer that the term "Huron shale" of Newberry can stand as the name of this formation, for as Dr. Orton has said in discussing the name, "It would have served the interest of geological classification much better to have replaced the term altogether than to have restricted it to a small fraction of what it was originally made to cover."[9] Neither does it appear that either of the other names is applicable for this shale. Further field work in northern Ohio is necessary before a satisfactory name and classification can be proposed for these shales; therefore, for the present, the name "Huron shale " is retained.

---

[1] Rept. Geol. Surv. Ohio, Vol. I, Part I, 1873, p. 70.
[2] Letter of June 13, 1903.
[3] Mich. Geol. Surv., Rept. State Board for 1891 and 1892, p. 66.
[4] Letter of April 20, 1903.
[5] Ann. Rept. Geol. Surv. Ark., 1890, Vol. I, July, 1891, p. 124.
[6] *Michigan Miner*, Sept. 1, 1901, p. 9; Rept. State Board Geol. Surv. Mich., for 1901, 1902, pp. 66, 209, f. n. 48; and Russell in Twenty-second An. Rept. U. S. Geol. Surv., Part III, 1902, pl. XLIV, p. 668.
[7] Fifth Ann. Rept. Geol. Surv. Ind., p. 158.
[8] Ind. Dept. Geol. and Nat. Res., Twenty-fifth Ann. Rept., 1901, pp. 562–565.
[9] Rept. Geol. Surv. Ohio, Vol. VI, 1888, p. 24.

In 1903 Dr. George H. Ashley published the statement that "at Mr. Hopkins' suggestion the name 'Huron' has been adopted" for a group of the Lower Carboniferous rocks of southern Indiana.[1] This name was clearly preoccupied for a geological formation and yet Professor T. C. Hopkins used it on his "Geological Map of Indiana," published in 1904, and gave a description of the formation under the heading "The Huron Group" in the state report of that year.[2]

21. The local names of Delaware and Columbus limestones are used for the Devonian limestones of Ohio instead of Onondaga (Corniferous) of the New York classification, partly because it is probable that the Delaware limestone ought to be correlated with rocks of later age than the Onondaga limestone, viz., the lower part of the Erian series of New York. The name Sandusky limestone antedated that of Delaware limestone by five years, and when it was described by Dr. Newberry, in 1873, it was supposed to apply to the upper subdivision of the Ohio Devonian limestone, which he stated "is the rock quarried at Sandusky and Delaware."[3]

The Delaware limestone was apparently named by Dr. Orton, in 1878, on account of "its occurrence at Delaware, and the extensive use made of it at that point."[4] Recently it has been shown that nearly all of the rock in Sandusky, to which Dr. Newberry gave the name "Sandusky limestone," belongs in the *lower* instead of the *upper* division of what he called the Corniferous limestone, and, hence, it appears to the writer that the name Sandusky limestone ought to be dropped and Delaware limestone, which was the next one proposed, adopted for this formation.[5]

In my paper on "The Nomenclature of the Ohio Geological Formaions," published in the *Journal of Geology* in 1903,[6] Sandusky limestone was used as the name for the upper formation of the Devonian limestone because, as there stated, it antedated Delaware limestone by five years and the error in correlation between the limestones of Sandusky and Delaware was not known to the writer.

22. Mather in 1859 in a "Concise Geological Section of the Rocks Perforated by the State House Artesian Well, at Columbus," used the name Columbus limestone for No. 3 of the section which was given as 138½ feet in thickness, the top of which was 138 feet below the surface and covered by 15 feet of "slate" above which was 123 feet of drift.[7]

The slate and Columbus limestone are again mentioned on p. 11, where he stated that they "approach in character, and may be equivalents to the Marcellus shales, and Corniferous limestones of the New York Geological Reports." It is evident that No. 3 of Mather's section included both the Delaware and Columbus limestones of Dr. Newberry's later classification, as Newberry stated in his section of the State House well where he called No. 3 the Corniferous limestone,[1] and which later he divided into the Sandusky and Columbus limestones.[2]

---

[1] Ind. Dept. Geol. and Nat. Res., Twenty-seventh An. Rept., 1902, p. 73. See the sub-heading "The Huron Group" on p. 71.

[2] *Ibid*., Twenty-eighth An. Rept., 1903, pp. 64–67.

[3] Rept. Geol. Surv. Ohio, Vol. I, Part I, p. 143.

[4] *Ibid*., Vol. III, 1878, p. 606.

[5] For a complete discussion of this matter see *Jour. Geol*., Vol. XIII, 1905, pp. 413-443.

[6] Vol. XI, p. 519 and see pp. 521 and 537.

[7] Report on the State House Artesian Well at Columbus, Ohio, p. 6.

Mather's article was simply a report to the State House Commissioners and the terrane is very imperfectly defined. Since it has never been recognized in geological literature ,while the Columbus limestone of Newberry is a well known formation,it is not considered necessary to recognize Mather's name, and therefore Newberry's name of Columbus limestone is retained for this formation.

Mr. George N. Knapp named a Cretaceous formation of New Jersey the "*Columbus* bed (sand)," which was published in 1899 in a report by Professor Rollin D. Salisbury.[3]

The name "Columbus bed" appeared for this formation in Mr. Lewis Woolman's article on "Artesian Wells" in the New Jersey report for 1900.[4]

Dr. Heinrich Ries has used the term "Columbus sand" for this formation in his report on "The Clays and Clay Industry of New Jersey,"[5] which was also used by Professor Stuart Weller in his paper on "The Classification of the Upper Cretaceous Formations and Faunas of New Jersey."[6]

The name Columbus bed or sand when published in 1899 was clearly preoccupied by Columbus limestone of 1873 and hence it must fall.

23. In the Ohio reports this mass of limestone with some included beds of gypsum and sandstone has frequently been termed "the Lower Helderberg or Waterlime formation."[7] The Lower Helderberg limestones, however, now represent the Helderbergian series of the New York classification, while the Waterlime belongs in the next older series, the Cayugan. It has been clearly shown, however, by Mr. C. A. Hartnagel that the Cayugan series of New York contains three distinct waterlime horizons, which are, in ascending order, the Bertie at the top of the Salina beds, the Rondout and "the Manlius waterlimes above the horizon containing what is now recognized as the Manlius limestone fauna."[8] Mr. Hartnagel also shows that the Helderbergian series, Manlius limestone and Rondout waterlime thin out and disappear before Buffalo, New York, is reached, where generally the Onondaga limestone directly overlies the Cobleskill limestone.[9] In the eroded surface of the Cobleskill limestone are hollows containing deposits of sand, which most of the geologists who have recently studied this locality regard as representing the horizon of the Oriskany sandstone.[10] In the Buffalo region the Cobleskill limestone

---

[1] Rept. Geol. Surv. Ohio, Vol. I, Part I, 1873, p. 114.

[2] *Ibid.*, p. 143.

[3] Geol. Surv. N. J., Ann. Rept. State Geologist for 1898, pp. 35–36.

[4] *Ibid.*, Ann. Rept. State Geologist for 1900, 1901, p. 147.

[5] *Ibid.*, Vol. VI Final Rept. State Geologist, 1904, p. 153, f. n. 2 and p. 156

[6] *Jour. Geol.*, Vol. XIII, 1905, pp. 75–76.

[7] Rept. Geol. Surv. Ohio, Vol. VII, pp. 4, 14.

[8] N. Y. State Mus., Bull. 69, 1903, p. 1171.

[9] *Ibid.*, p. 1139.

[10] See Dr. Clarke in Mem. N. Y. State Mus., Vol. III, No 3, 1900, p. 96.

directly overlies the Bertie waterlimes, which is the upper member of the Salina beds. The formations represented in the vicinity of Buffalo, together with their stratigraphy, indicate that in a general way the deposits of this formation in Ohio may be correlated with the Salina beds of New York.

The correlation of the Ohio formation, however, with that of New York is somewhat indefinite and it appears advisable to adopt the name applied by Dr. Lane to these rocks in southeastern Michigan. The name "Monroe Beds" first appeared in a "Geological column" prepared by Dr. Lane and incorporated in a report of Dr. Wadsworth published in 1893.[1] In this publication the formation was not defined; but in 1895 it was fully described by Dr. Lane and shown to include all the rocks between the Niagara and Dundee limestones of Michigan.[2] In 1894, however, Mr. Darton named and described the Monroe shales, a Devonian formation of southeastern New York,[3] and on this account there was some uncertainty whether the Michigan name would be retained or not. The question was submitted to Mr. Bailey Willis, Chairman of the Committee on Geologic Names of the U. S. Geological Survey, who has sent me the following answer:

"The Committee on Geologic Names on May 12th took action on the validity of the term *Monroe* in several publications of 1891, 1892 [1893], and 1895, as the name of a group of rocks distinguished in southern Michigan, as against the standing of the name published in 1894 for a shale formation in southeastern New York.

"The Committee recommended that the *Monroe group* of southern Michigan should retain the name, and this action has been approved for official publications of the Geological Survey.

"The conclusion was reached on the ground that priority and prescription, or established usage, are combined in the Michigan application of the term in such a way as to make its continued use more desirable than that of Monroe shale in New York; but the case was not considered one in which priority was so definitely obvious as to justify the conclusion on the ground of the publication of 1891–92 [1893] only, since in that publication the definition was inadequate."[4]

In 1898 Professor Grabau proposed the name Greenfield limestone for the Ohio Waterlime from the town of that name in the northeastern corner of Highland county, in southern Ohio, where the limestone is well shown and extensively quarried.[5] This is certainly an appropriate name for the formation in central and southern Ohio which will be available in case further study shows that Monroe is not a suitable name for the Waterlime in this section of the state.

---

[1] Rep. State Board Geol. Surv. for 1891 and 1892, p. 66. Dr. Wadsworth states in a letter to Dr. Lane that "the late winter or early spring of 1893 was the date of publication."

[2] Geol. Surv. Mich., Vol. V, Part II, pp. 26–28.

[3] Bull. Geol. Soc. Amer., Vol. 5, March, 1894, p. 374.

[4] Letter of May 18, 1903.

[1] *Science*, *N. S.*, Vol. VIII, p. 800.

It is to be remembered, however, that Dr. Orton published the name "Greenfield Stone" in 1871 in a chart of the "Geological Series of Highland County;"[1] but did not use it as a formation name since he described it under the name of Helderberg limestone.[2]

24. The Monroe, however, in northwestern Ohio contains a light colored very quartzose rock which in 1888 was named the Sylvania sandstone by Dr. Orton,[3] from the exposure in a quarry about four miles west of Sylvania village in Sylvania township, Lucas county. The stratum was first described by Mr. G. K. Gilbert in 1873 who referred it to the "Corniferous group" with a thickness of 20 feet,[4] although on the accompanying geological map of Lucas county it is apparently the division termed the Oriskany sandstone and represented as crossing the county from the Michigan state line to the Maumee river on the south. The same terrane was represented in Wood county, south of the Maumee river,[5] and perhaps in some of the other counties of northwestern Ohio. The sandstone thickens as followed to the northeastward in Michigan and Mr. Sherzer gives it as 50 feet in thickness in Exeter township, Monroe county, the one immediately north of Lucas county, Ohio, while still farther north it is given as ranging from 95 to 130 feet in thickness.[6] On Mr. Sherzer's geological map of Monroe county the "Monroe beds" are represented in five divisions and the only one to which a geographic designation is given is the Sylvania sandstone. The dolomitic limestones below the Sylvania sandstone are separated by an oölitic bed which is given as about 100 feet below the sandstone and from twenty inches to two feet in thickness.[7]

It appears to the writer that the Monroe formation of northwestern Ohio may probably be divided into at least three members. For the upper one the name Lucas limestone is proposed from Lucas county, which it crosses from north to south. It may be studied at the typical locality in Sylvania township described by Mr. Gilbert in 1873, where are the extensive quarries of the Toledo Stone and Glass Sand Company, and the place now named Silica, or in the banks of the Maumee river bordering Providence township. It includes all the rocks between the top of the Sylvania sandstone and the base of the Columbus limestone or the base of the formation which Dr. Lane in Michigan has named the "Dundee limestone."[8] The middle member is the Sylvania sandstone of Dr. Orton which was called the "Oriskany sandstone" on the geological maps of Lucas and Wood counties. The rocks below the sandstone are shown at various localities on both banks of the Maumee river from the vicinity of the Providence–Waterville township line, Lucas county, to Maumee. Provisionally this member is termed the Tymochtee, a name given in 1873 by Prof. N. H. Winchell to the thin bedded Waterlime exposed on the banks of this creek in Crawford township, Wyandot county.[1] The limits of the "Tymochtee slate" were not definitely fixed by Winchell and further investigation may render it inadvisable to retain this name. Professor Winchell, however, used it for the thin bedded Waterlime in several of the northwestern counties and compared the beds of this character in Wood county with it.[2]

---

[1] Geol. Surv. Ohio, Rept. Prog. in 1870.
[2] *Ibid.*, pp. 287–294.
[3] Rept. Geol. Surv. Ohio, Vol. VI, p. 18.
[4] Rept. Geol. Surv. Ohio, Vol. I, Part I, p. 576.
[5] *Ibid.*, Vol. II, Part I, 1874, op. p. 368.
[6] Geol. Surv. Mich., Vol. VII, Part I, 1900, p. 54.
[7] *Ibid.*, p. 61.
[8] Mich. Geol. Surv. Rept. State Board for 1891, 1892 and 1893, p. 66; Geol. Surv. Mich., Vol. V, Part II, 1895, p. 25; and Sherzer in *ibid.*, Vol. VII, Part I, 1900, p. 35.

Dr. Lane in his last Annual Report subdivides the Monroe formation of Michigan into three divisions which are named in ascending order the Salina, Sylvania and Lucas.[3] It appears from his table that he correlates that part of the Monroe formation below the Sylvania sandstone with the Salina beds of New York.

25. In the New York classification this division has been abandoned and the two older ones of Rochester shale and Lockport dolomite accepted as formations; the former representing the lower and the latter the upper part of the old "Niagara group." At present we are unable to correlate precisely the Ohio rocks with these two eastern formations, therefore the more general term of Niagara which has been used for this mass of rocks in Ohio is retained for the time being.

26. The following subdivisions of the "Niagara group" have been recognized and defined in southwestern Ohio; but whether these shall be considered as formations or members or part of them be grouped together to form new formations, we are not prepared to state at present. It does not appear probable that all of these divisions can be recognized in northern Ohio.

27. Dr. Aug. F. Foerste in 1897 named the lower Niagaran deposits of Indiana the "Osgood or Cystidean beds," which he divided in places into the Lower Osgood clay, the Osgood limestone and the Upper Osgood clay from outcrops near the town of that name in southern Indiana.[4] Later he stated that the Niagara shale of the Ohio reports "evidently corresponds stratigraphically to the Osgood beds of Indiana" and apparently refers the Dayton limestone, Orton 1870, which occurs at the base of the shale, to the same division.[5] He also stated that "the West Union cliff may correspond to the limestone courses in the upper part of the Osgood beds in Indiana and western Kentucky, but it has so far not been sufficiently investigated to admit of correlation."[6] Finally, regarding the correlation of these beds with the New York formations Dr. Foerste has written as follows; "As far as may be determined from the evidence at hand, the Osgood bed contains a part of the fauna of

---

[1] Rept. Geol. Surv. Ohio, Vol. I, Part I, p. 633.

[2] *Ibid.*, Vol. II, Part I, p. 375.

[3] Rept. State Board Geol. Surv. Michigan for the year 1903, 1905, p. 288.

[4] Ind. Dept. Geol. and Nat. Res. Twenty-first Ann. Rept., p. 217 and see description of the subdivisions on pp. 227–230.

[5] *Ibid.*, Twenty-fourth Ann. Rept., 1900, pp. 44, 80.

[6] *Loc. cit.*, p. 80.

the lenses at the top of the Clinton and of the lower half of the Rochester shales in New York, a part of this fauna beginning at the top of the Clinton in that state."[1]

28. Regarding the correlation of this limestone with the Clinton of New York, Dr. Foerste has stated that "the Clinton of Ohio, Indiana and Kentucky appears to have attained the stage of development equivalent to that of the Clinton of New York, below the lenses, but does not contain such species as *Pentamerus oblongus, Atrypa reticularis, Spirifer radiatus, Sp. niagarensis,* which in the west begin their existence in the Osgood bed. The faunal elements of the Clinton in the two areas are different and a more exact comparison is at present impossible."[2]

29. The Canadian Survey has shown that the Medina formation may be traced by surface outcrops from Niagara river across Ontario and along the western shore of Georgian bay.[3] Later the red rocks penetrated in deep wells in southern Ontario,[4] the Lower Peninsular of Michigan,[5] and Ohio[6] have been referred to the Medina formation. Dr. Lane, however, stated that in Michigan the Medina shale "both lithologically and in the driller's records, is quite as likely to go with those below it. It is really a transition bed."[7] There is evidently uncertainty regarding the age of the red shales penetrated in the oil and gas wells of northwestern Ohio, but in the absence of positive knowledge they are left provisionally in the Upper Silurian and called Medina with a query.

30. In 1896 Dr. Foerste named an "argillaceous limestone," between three and six feet in thickness, the Belfast bed from exposures near the small town of that name in the southern part of Highland county.[8] At that time it was supposed to represent the deposits "formerly called the Medina" by Dr. Orton;[9] but later Foerste learned that it was superjacent to them and made the following correction; "The four to five feet of sandy limestones which I here [in above paper of 1896], for the first time, call the Belfast bed, are not the typical Medina rocks of Professor Orton and other writers on Ohio geology, and are therefore not the rocks formerly called Medina in Ohio."[10] In the writer's opinion it is a question whether the Belfast bed is of sufficient thickness and importance to be given the rank of a formation.

31. At present whether the line of separation between the Upper and Lower Silurian should be drawn at the top or bottom of the Belfast bed is a matter of uncertainty. Dr. Foerste states, "I am not

---

[1] *Am. Jour. Sci.*, 4th ser., Vol. XVIII, 1904, p. 340.

[2] *Ibid.*, p. 340.

[3] Geol. Surv. Canada, Rept. Prog., from Commencement to 1863, pp. 312–321; and also see Atlas Geol. Map of Canada, 1864.

[4] Brumell: *ibid.*, Ann. Rept. N. S., Vol. V. Part II, 1892, p. 52, etc .

[5] Lane: Geol. Surv. Mich., Vol. V, Part II, 1895, p. 30 and plates.

[6] Orton: Rept. Geol. Surv. Ohio, Vol. VI, 1888, p. 11, etc., as well as in later reports of the Ohio Survey.

[7] Geol. Surv. Mich., Vol. V, Part II, p. 30.

[8] *Jour. Cin. Soc. Nat. Hist.*, Vol. XVIII, p. 164.

[9] *Ibid.*, p. 163.

[10] Ind. Dept. Geol. and Nat. Res., Twenty-fourth Ann. Rept., 1900, p. 67.

certain as to the age of the Belfast bed myself," and he also says that "It is the only bed which may be Lower Silurian and which may be of Medina age."[1] And in an earlier paper Dr. Foerste stated that "The Clinton formation of Ohio is the lowest formation in that state, belonging without question to the Upper Silurian. Between the Clinton of Ohio and the upper fossiliferous beds of the Cincinnati formation occur in many parts of the state a series of unfossiliferous beds which it is difficult to assign definitely either to the Upper or to the Lower Silurian."[2]

The fossils of the Belfast bed, as reported by Dr. Foerste, are *Halysites catenulatus*, a Clinton and Niagara coral not known in the Cincinnatian series of Ohio, Indiana, or Kentucky, annelid teeth which are identical specifically with forms found in undoubted Lower Silurian limestones, and an *Orthis* allied to *O. calligramma* of the Clinton.[3]

Mr. John M. Nickles apparently puts the Belfast bed of Foerste in the Lower Silurian, since he has written as follows concerning it: "This Belfast Bed the writer would include in the Madison [this terrane was renamed the Saluda bed, on account of the preoccupation of Madison as the name of a geological division, and forms the upper part of the Lower Silurian]. It is immediately overlain by the Clinton, so that the Medina formation is lacking in the Cincinnati area."[4]

32. By some geologists this system is called the Ordovician, a name introduced by Lapworth in 1879 for the Lower Silurian of Murchison, which Sedgwick called upper Cambrian. This usage, however, is strenuously opposed by the distinguished British geologist, and former Director-General of the Geological Survey of Great Britain and Ireland—Sir Archibald Geikie—who has written as follows: "This proposal, which was honestly intended to obviate confusion and to promote the progress of the science, was, in my opinion, especially unjust to Murchison. The division of 'Lower Silurian' had the claim not only of priority, but of having had its component members defined by the author of the Silurian system in the early years of his investigation, and accepted by geologists all over the world."[5] In another place in this same report Geikie said, "Murchison's 'Lower Silurian' has by many writers been replaced by 'Ordovician', and his 'Upper Silurian' is in a similar manner being ousted by some other term, so that if this process of substitution is perpetuated the names given by the illustrious author of the 'Silurian system' will disappear from current geological literature. I shall continue to employ Murchison's terminology, which has the claim of priority, and in my opinion is perfectly sufficient for the requirements of science."[6]

When Ordovician is used in place of Lower Silurian then the term Silurian is usually applied to the division which Murchison named the

---

[1] *Ibid.*, p. 68.

[2] *Jour. Cin., Soc. Nat. Hist.*, Vol. XVIII, 1896, p. 163.

[3] *Ibid.*, pp. 163, 165.

[4] *Am. Geol.*, Vol. XXXII, 1903, p. 212.

[5] Text-Book of Geology, 4th ed., Vol. II, 1903, p. 917.

[6] *Ibid.*, p. 934. Also see *ibid.*, 3rd ed., 1893, p. 738 for an earlier statement of a similar opinion by Dr. Geikie.

Upper Silurian. A very cogent reason has been presented against this arrangement by Dr. Wm. B. Clark, who states that "I prefer the use of Lower Silurian to Ordovician, as I do not think the term Silurian of Murchison can with propriety be restricted to the Upper Silurian. If the Upper and Lower Silurian are to be raised to period position, and Ordovician used, I think some other name should be substituted for Sliurian."[1]

The New York geologists, however, in 1842 divided the older Paleozoic rocks of that state into two divisions which they named the Champlain and Ontario.[2] These two names have been given precedence by Dr. John M. Clarke—the present State Geologist of New York—over the names Lower Silurian or Ordovician and Upper Silurian or Silurian.[3] Finally in discussing this subject Dr. Clarke has made the following statement: "We should say alternatively, Silurian or Ontarian, or to conform with recommendations of the International Congress of Geologists Siluric or Ontaric. We should not say, however, Lower Siluric or Champlainic, but always Champlainic, for the original Silurian was only what is now known as Upper Silurian."[4]

33. The mottled clays and thin arenaceous limestones which outcrop in southwestern Ohio and which in the Ohio reports have generally been termed the Medina shales—the lowest formation of the Upper Silurian in western New York—apparently belong in the upper part of the Lower Silurian. Dr. Foerste has studied these beds quite carefully and reports in them several species of fossils, which are of Lower Silurian age. He states that "It should be remembered that the identification of the Medina in Ohio has not only been solely lithological, but has been practically made upon the sole basis of color. Had the clays near the top of the Lower Silurian not had a single touch of red or purple color, it is probable that the name Medina would have never been applied to them."[5] While later in the same article it is stated that "The red, purple and otherwise colored clays below the Belfast bed and its equivalent are, however, Lower Silurian, as is shown by the presence in them of Lower Silurian fossils."[6] The fauna, as reported by Dr. Foerste, is not very extensive, and includes two brachiopods, *Orthis* (*Hebertella*) *occidentalis,* which is not known above the Richmond formation and "Lower Silurian forms of *Orthis* (*Platystrophia*) *biforata,*"[7] although it must be remembered that this species occurs in the Clinton limestone,' 'bryozoans of Lower Silurian age," "annelid teeth such as are found in the Lower Silurian," corals as *Tetradium* and stromatoporoid sponges.[8]

These rocks were named the Madison beds by Dr. Foerste in 1897, on account of the typical exposures at Madison, Indiana; but the name was preoccupied as a geological term, for in 1875 Professor Irving named and described the Madison sandstone of Wisconsin. If this formation be a synonym for the Jordan sandstone which was named and described by Professor N. H. Winchell in 1874, then the name Madison is still preoccupied, for it was applied by Dr. Peale in 1893 to a Carboniferous formation of Montana. Dr. Foerste in some of his reports has used the name Cumberland sandstone, which was applied by Shaler in 1877 to the upper part of the Lower Silurian rocks exposed along the Cumberland river in southern Kentucky, as apparently equivalent to the Madison beds; but in a late paper he states "that the term Cumberland sandstone includes a much larger series of rocks than the name Madison bed."[1] Finally he gives his opinion "that the major part of the rock designated as the Cumberland sandstone by Professor N. S. Shaler must have been of Lorraine age, and if any part of the Richmond is to be included under this name this is due rather to accident than to the original intention of the author."[2] In this paper Dr. Foerste recognized that the name Madison was preoccupied and stated, "It is therefore considered desirable to change the name of the beds at the top of the Richmond, hitherto called the Madison beds; the name Saluda bed is therefore introduced, taken from Saluda creek, six miles south of Hanover [Jefferson county], Indiana."[3]

---

[1] *Jour. of Geology*, Vol. VI, 1898, p. 342.
[2] Emmons; Geol. N. Y., Part II, p. 429, and Vanuxem, *ibid.*, Part III, p. 13.
[3] Handbook 19, N. Y., State Mus., 1903, pp. 9–12.
[4] High School Bull. 25, [N. Y.], Proc. Eighth Ann. Con. N. Y. State Science Teachers' Asso., Dec 1903, p. 499.
[5] Ind. Dept. Geol. and Nat. Res., Twenty-fourth Ann. Rept., 1900, pp. 67, 68.
[6] *Ibid.*, p. 68.
[7] *Jour. Cin. Soc. Nat. Hist.*, Vol. XVIII, 1896, p. 165.
[8] Ind. Dept. Geol. and Nat. Res., Twenty-fourth Ann. Rept., 1900, pp. 65, 66.
[9] *Ibid.*, Twenty-first Ann. Rept., 1896, pp. 218, 220.

Mr. John M. Nickles believes that Madison ought to be retained as the name of these beds as may be seen from the following quotation; "The first use of the name Madison for a geologic formation was by BORDEN in 1874, a year before Madison was applied to a Potsdam formation in Wisconsin (*Fifth Ann. Rep. Geol. Sur. Indiana,* 1874, p. 139). He used it in a vague way for the Cincinnati group in southeastern Indiana, MR. FOERSTE'S use of Madison is then tantamount to a revival of an old term, but with a more precise, restricted application, and in the writer's judgment the name Madison should be retained."[4] The exact statement of Borden, however, is as follows; "The general character of the Madison rocks, which belong to the Cincinnati group (in great force at Cincinnati), (Hudson River so called, from being found on the Hudson River, N. Y.), as exposed on the bluffs of Camp Creek, are a thin stratified dark blue crystalline limestone, with intermediate layers of a lighter colored coarse grained limestone."[5] It will be seen from the above quotation that Borden did *not* use the term "Madison rocks" "in a vague way for the Cincinnati group," but clearly considered them as only a part of that group. In the writer's opinion, however, the term was not used as the name of a definite geological division and in any case was too imperfectly limited and described to be revived and replace later and definitely described formations of the same name.

---

[1] Bull. Geol. Soc. Amer., Vol. 12, 1901, p. 436.
[2] *Am. Geol,* Vol. XXX, December 1902, p. 368.
[3] *Ibid.*, p. 369.
[4] *Am. Geol.*, Vol. XXXII, 1903, p. 210, f. n.
[5] Fifth Ann. Rept. Geol. Surv. Ind., p. 139.

The writer is not certain that this bed in Ohio merits a separation from the Richmond formation, as is indicated by the dotted line on the chart. In fact Dr. Foerste states that "There is no doubt that in southern Indiana and northern Kentucky the Madison beds are merely the upper unfossiliferous part of the Richmond group,"[1] and in proposing the Saluda bed he speaks of the hitherto called Madison beds as "at the top of the Richmond."[2]

Mr. Nickles refers the Belfast bed to the Madison,[3] which he considers a formation.[4] The Richmond he ranks as a group[5] and divides it into four subdivisions of which the Madison is the highest.[6]

34. The rocks of southwestern Ohio described in the later volumes of the Ohio reports under the name "Hudson River group or series" are here given as the Richmond and Lorraine formations and Eden shale. Clarke and Schuchert did not use Hudson River in their revised classification of the New York series and formations in 1899, stating that "It is becoming increasingly evident that the great mass of shale in the Mohawk and Hudson river valleys which was designated at an early date by this term [Hudson River beds] is resolvable into horizons extending from the middle Trenton to and including the Lorraine beds. At present it seems unlikely that when this determination of horizons has been carried through the series any part will remain to which the original term can be applied by virtue of its distinctive fauna, though it may still serve to designate a facies of the formations mentioned."[7] Finally, Dr. Ruedeman, after an exhaustive study of the Hudson River beds near Albany, N. Y., has reached the conclusion that "On account of the fact that the mass of beds hitherto called Hudson River shales and correlated with the Lorraine beds of central New York, is composed of terranes ranging from the Lorraine to the lower Trenton, and on account of the lack of a fully representative fauna and of a complete section of the Lorraine portion of these terranes, it is proposed to drop the term 'Hudson river shales,' for the uppermost part of the Lower Siluric, and the term 'Hudson river group,' for the Utica and Lorraine beds."[8] Clarke and Schuchert have adopted Cincinnatian as the name for the series and period composed of the Utica, Lorraine and Richmond formations[9] and Mr. Nickles has given an excellent historical account of the names used for the Lower Silurian formations of Ohio.[10]

The upper division of the "Cincinnati group" was named the "Lebanon beds" by Dr. Orton in 1873;[11] but the name was preoccupied, for

---

[1] Bull. Geol. Soc. Amer., Vol. XII, 1901, p. 436.
[2] *Am. Geol.*, Vol. XXX, 1902, p. 369.
[3] *Ibid.*, Vol. XXXII, 1903, p. 212.
[4] *Ibid.*, pp. 202, 210.
[5] *Ibid.*, p. 203.
[6] *Ibid.*, p. 218.
[7] *Science, N. S.*, Vol. X, p. 877.
[8] Bull. N. Y. State Mus., No. 42, Vol. 8, 1901, p. 568.
[9] *Science, N. S.*, Vol. X, 1899, p. 876.
[10] *Jour. Cin. Soc. Nat. Hist.*, Vol. XX, 1902, pp. 52–60. A briefer account of the names used for "the subdivisions of the Cincinnati group in Ohio" by Dr. Foerste may be found in the *Jour. Geol.*, Vol. XI, 1903, pp. 29–33.
[11] Rept. Geol. Surv. Ohio, Vol. I, Part I, p. 371.

Proffessor Safford in 1851 had applied it to a still older limestone of central Tennessee, using it for the two upper divisions of his Stones River group.[1] For the above reason Professor N. H. Winchell and Mr. E. O. Ulrich in 1897 renamed it the Richmond group on account of the excellent exposures at Richmond, Indiana.[2]

Mr. Nickles has published an excellent account of the oldest four formations of the Ohio scale which are admirably exhibited in the vicinity of Cincinnati and at other localities in southwestern Ohio, for which he used the names Richmond, Lorraine, Utica and Trenton.[3]

35. In the adjoining area of southeastern Indiana, Dr. Foerste recognized four Ordovician (Lower Silurian) formations for which in 1904 he used the names Trenton, Utica, Lorraine and Richmond,[4] and so represented them on the last "Geological Map" of that state.

Since the manuscript for this chapter was transmitted to the printer Dr. Foerste has published an article on "The Classification of the Ordovician rocks of Ohio and Indiana,"[5] in which he arrives at quite different conclusions regarding the correlation and names for these formations, Dr. Foerste's statement is as follows: "In the twenty-eighth annual report of the Indiana Geological Survey, published in 1903 [1904], the classification proposed by Nickles was adopted without change. Since the publication of this report, however, several changes in the nomenclature have seemed advisable. Some of these are due to the practice. which recently has become more general, of adopting distinct names for formations which formerly were considered approximately identical, whenever a study of their fossil faunas indicates that these formations were deposited in zoological provinces essentially distinct. Now, a study of the fossil lists given by Nickles in his 'Geology of Cincinnati' indicates that the rocks at Cincinnati identified as Lorraine and Utica contain faunas so different from the typical Lorraine and Utica faunas of New York as to warrant the application of the principle above stated. For this reason the name *Maysville* is here suggested for the strata at Cincinnati hitherto identified as Lorraine. Along the railroad south of Maysville, Kentucky, from the first cut a little over a mile from town to the overhead bridge a mile north of Summit, a magnificent series of exposures gives a complete section of all the subdivisions of the Maysville division, from the Mount Hope bed to the top of the bed formerly known as Warren."[6]

36. In 1888 Mr. E. O. Ulrich after a careful study of the rocks in the vicinity of Cincinnati concluded that "if not all, at least a large proportion of the strata comprised in beds XI [this division of Mr. Ulrich's included the lower 275 feet of rocks shown at Cincinnati, the lower 50

---

[1] *Am. Jour. Science*, 2d ser., Vol. XII, pp. 353–355.
[2] Geol. Minn., Vol. III, Part II, pp. LXXXIX, CIII.
[3] *Jour. Cin. Soc. Nat. Hist.*, Vol. XX, 1902, pp. 49–101.
[4] Ind. Dept. Geol. and Nat. Res., Twenty-eight Ann. Rept., pp. 21-27.
[5] *Science*, N. S., Vol. XXII, Aug. 4, 1905, pp. 149-152.
[6] *Loc. cit.*, pp. 149, 150.

feet of which he called XIa and the succeeding 225 feet XIb] are equivalent to the black or Utica shales underlying Findlay."[1] In 1897 Winchell and Ulrich unhesitatingly correlated the rocks of division XIb with the "Utica group" of New York, which they gave as over 250 feet in thickness,[2] while the lowest 50 feet exposed on the river bank opposite Cincinnati, or Ulrich's XIa, was correlated with the "Trenton group."[3] In 1902, however, Ulrich and Schuchert stated that they regarded "the Middle and Upper Utica of Nickles' Cincinnati section" as equivalent to the Frankfort shales of New York [which is one of the early terms applied to the local development of the Lorraine in central New York] stating that "the typical Utica" barely reaches Cincinnati, "though something like 300 feet thick in northwestern Ohio."[4] In 1904 Ulrich published "A Standard Time Scale of the Ohioan Province" in which the following classification occurs:

Cincinnatian {
Richmond.
Lorraine.
Eden or Frankfort.
Utica.[5]

Dr. Foerste has revived the name Eden for this formation, concerning which he has written as follows: "The name *Eden,* well defined by Orton in the first volume of the 'Geology of Ohio,' published in 1873, is revived for the strata which in the 'Geology of Cincinnati' are identified as Utica. Whether the clay bed, four or five feet thick, containing *Triarthrus becki,* at the base of the Eden division should be included in the Eden or not, is a question which requires further study. On the supposition that *Triarthrus becki* proves this clay layer to be of the same age as the Utica of New York, and that the Eden beds represent a later stage of deposition than the Utica of New York, the clay bed containing *Triarthrus becki* should be excluded from the Eden division.[5] The writer, however, is not prepared to assert that the clay bed in question is the only representative at Cincinnati of the considerable thickness of black shales struck in the gas and oil wells of northern Ohio, and there identified as Utica."[6]

37. The lower 50 feet of rocks exposed on the southern bank of the Ohio river opposite Cincinnati were correlated with the Trenton limestone of New York by Winchell and Ulrich in 1897[7] and the same formation is exposed on the northern bank of the Ohio river in Clermont county, particularly in the vicinity of Point Pleasant. Mr. Nickles also refers these beds at both localities to the Trenton formation.[8]

---

[1] *Am. Geol.*, Vol. I, p. 315.
[2] Geol. Minn., Vol. III, Part II, pp. LXXXIX, CII.
[3] *Ibid.*, p. CII, f. n.*
[4] N. Y. State Mus., Bull. 52, p. 643.
[5] U. S. Geol. Surv., Professional Paper No. 24, "Correlation Table" op. p. 90.
[6] *Science*, N. S., Vol. XXII, Aug. 4, 1905, p. 150.
[7] Geol. Minn., Vol. III, Part II, pp. XCVIII, CII, f. n.*
[8] *Jour. Cin. Soc. Nat. Hist.*, Vol. XX, 1902, pp. 60–62.

Fifty feet of rocks in the vicinity of Point Pleasant were named the Point Pleasant beds by Dr. Orton in 1873[1] and this name is used by Dr. Foerste in his 1905 article. He states that "the total thickness of rocks to be included in the Point Pleasant beds, if this name is to be retained, probably should be approximately one hundred feet."[2]

---

[1] Rept. Geol. Surv. Ohio, Vol. I, Part I, p. 373.

[2] *Science*, N. S., Vol. XXII, Aug. 4, 1905, pp. 151, 152.

GEOLOGICAL SURVEY OF OHIO

EDWARD ORTON, JR., State Geologist

FOURTH SERIES, BULLETIN No. 8

SALT DEPOSITS
AND THE SALT INDUSTRY IN OHIO

BY

JOHN ADAMS BOWNOCKER, D. Sc.,

Professor of Inorganic Geology, Ohio State University

Published by Authority of the Legislature of Ohio, Under the Supervision of
the State Geologist

COLUMBUS, OHIO, JUNE, 1906

GEOLOGICAL SURVEY OF OHIO

EDWARD ORTON, JR., State Geologist

FOURTH SERIES, BULLETIN No. 8.

SALT DEPOSITS
AND THE SALT INDUSTRY IN OHIO

BY

JOHN ADAMS BOWNOCKER, D. Sc.,

Professor of Inorganic Geology, Ohio State University.

Published by Authority of the Legislature of Ohio, Under the Supervision of the State Geologist.

UNIV. OF CALIFORNIA

COLUMBUS OHIO, JUNE, 1906

Printed by the Springfield Publishing Company,
Springfield, Ohio.

LETTER OF TRANSMITTAL.

To His Excellency, JOHN M. PATTISON, *Governor of Ohio:*

SIR:—I have the honor to present to you herewith, the eighth bulletin of the fourth series of the publications of the Geological Survey of Ohio. The subject of the bulletin is the "Salt Deposits and the Salt Industry in Ohio," and it has been prepared by Professor John A. Bownocker, B. Sc., Professor of Geology in the Ohio State University. This subject was made the basis of a chapter by Willis T. Root, E. M., in Volume VI, published in 1888. The reason for again reporting upon it is that the old industry existing at that time is now practically extinct and a new industry on a wholly different basis has since sprung up. The new industry promises to become a very important one, and for that reason this report has been authorized and prepared. In my opinion, the subject has been well handled and will set forth what is now available on this subject in a useful way.

I have the honor to be,

Yours very respectfully,
EDWARD ORTON, JR., E. M.,
State Geologist.

Ohio State University.
June, 1906.

OFFICERS OF THE SURVEY.

EDWARD ORTON, Jr., E. M.,................................State Geologist

CHARLES SMITH PROSSER, D. Sc.........................Assistant Geologist
Areal and Stratigraphical Geology.

JOHN ADAMS BOWNOCKER, D. Sc.......................Assistant Geologist
Economic Geology.

NATHANIEL WRIGHT LORD, E. M......................Consulting Chemist
Constitution and Utilization of Coals.

METTA L. SEYMOUR................................Stenographer and Clerk

ANNOUNCEMENTS BY THE STATE GEOLOGIST.

BULLETIN 8.

This bulletin has been prepared in response to a number of calls for exact information on the subject of the new rock salt discoveries in northeastern Ohio. The excellent work done by Mr. W. J. Root in 1888 on the salt industry as it then existed made it seem improbable that the subject would require reconsideration in the future. But geology is full of surprises of this sort. The drill brought to light in 1884 the existence of oil and gas underneath the level prairies of northwestern Ohio, a region where no geologist would have dared to prophesy the least encouragement for such resources. And similarly, the drill in northeastern Ohio has found large deposits of rock salt where an orderly sequence of shales, sandstones and limestones was expected. True, there is good geological precedent for the existence of these salt beds, and now that we know that they are there, it seems quite a matter of course that it should be so, but, the fact remains that geology did not lead any one to predict their discovery, which was due to search for oil and gas.

The discovery of this rock salt came at a time when the old industry, which had flourished since the days of the pioneers, was in the last stages of decadence. This industry, founded on the weak superficial brines of the coal-measures, which were often discovered from the "salt-licks" of the deer and buffalo, had been of the greatest importance and service to the settlers in early times, when all salt was almost a luxury and when it was generally carried over the mountains on horseback or in wagon trains. The discovery and manufacture of native salt in Ohio played a considerable part in the development of the state.

But, in the course of events, the discoveries of rock salt in Michigan, and the production of saturated brines instead of the weak brines of Ohio, soon gave that state an advantage which Ohio manufacturers could not meet. The cheap fuel of Michigan was also in her favor—the slabs and dust from the saw-mills gave a good combustible of which they were actually anxious to get rid. Michigan salt began crowding Ohio salt to the wall in the 70's and in 1890 there remained but a few plants still struggling along.

The revival of this industry on its present apparently permanent basis means much to Ohio. It means not only that we shall preserve our position or improve it, in the industrial competition, but also that allied industries also may thrive—for instance, the manufacture of soda-ash, the manufacture of glass and soap and many other industries using the element sodium in some of its saline forms.

Professor Bownocker has pursued this study with diligence in the summers of 1904 and 1905 and has presented the facts in a clear, succinct manner which the practical men will enjoy, as well as those whose interests are more on the technical side.

FORMER PUBLICATIONS OF THE SURVEY.

The work performed by the First, Second and Third organizations of the Geological Survey of Ohio is comprehended in the following list of publications:

FIRST GEOLOGICAL SURVEY 1837-1838

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
First Annual Report........	1838	134	5,000	W. W. Mather
Second Annual Report......	1838	236	5,000	W. W. Mather

SECOND GEOLOGICAL SURVEY 1869-1888.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
Report of Progress.........	1869	176	14,500	J. S. Newberry
Report of Progress.........	1870	568	14,500	J. S. Newberry
Report of Progress.........	1871	3	400	J. S. Newberry
Geology of Ohio, vol. I, part I, Geology................	1872	680	20,000	J. S. Newberry
Geology of Ohio, vol. I, part II, Paleontology	1873	*401 †49	20,000	J. S. Newberry
Geology, of Ohio, vol. II, part I, Geology...............	1874	701	20,000	J. S. Newberry
Geology of Ohio, vol. II, part II, Paleontology	1875	*431 †59	20,000	J. S. Newberry
Geology of Ohio, vol. III, Geology	1878	958	20,000	J. S. Newberry
Geological Atlas of Ohio....	1879		5,000	J. S. Newberry
Geology of Ohio, vol. IV, Zoology and Botany......	1882	1,070	20,000	J. S. Newberry
Geology of Ohio, vol. V, Economic Geology...........	1884	1,124	10,000	Edward Orton
Preliminary Report on Petroleum and Inflammable Gas	1886	76	2,500	Edward Orton
Geology of Ohio, vol. VI, Economic Geology.......	1888	831	15,000	Edward Orton

*Pages. †Plates.

THIRD GEOLOGICAL SURVEY 1889-1894.

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
First Annual Report........	1890	323	10,000	Edward Orton
Geology of Ohio, vol. VII, part I, Economic Geology.	1893	290	2,500	Edward Orton
Geology of Ohio, vol. VII, (complete including part I)	1894	970	7,500	Edward Orton

FOURTH GEOLOGICAL SURVEY 1899———

Title of Volume.	Date of Issue.	Number of Pages.	Number of Copies Printed.	Geologist in Charge.
Bulletin 1—Oil and Gas.....	1903	320	8,000	Edward Orton, Jr.
Bulletin 2—Uses of Cement..	1904	260	6,000	Edward Orton, Jr.
Bulletin 3 { Manufacture of Cements	1904	391	4,000	Edward Orton, Jr.
Bulletin 4 { Limestones and Lime..........	1906	365	4,000	Edward Orton, Jr.
Bulletin 5—Sand-Lime Brick	1906	79	4,000	Edward Orton, Jr.
Bulletin 6—Bibliography ...	1906	—*	3,500	Edward Orton, Jr.
Bulletin 7 { Nomenclature of Geological Formations....	1905	36	3,500	Edward Orton, Jr.
Bulletin 8 { Salt Deposits and Salt Industry........	1906	42	3500	Edward Orton, Jr.

*In press.

DISTRIBUTION OF REPORTS.

First Geological Survey.—These volumes are out of print and rare. They can only be procured from dealers in second-hand libraries and are difficult to obtain even there.

Second Geological Survey.—These volumes were all distributed at the time of their issue. The State retained no stock for meeting future demands, so that no copies of any of these volumes can be obtained from the office of the State Geologist. They can be bought in many second-hand book stores, and from dealers in old libraries, at prices ranging from a few cents to two or three dollars per volume, according to rarity and demand. Volumes V and VI are the rarest and most sought for.

Third Geological Survey.—These volumes were all distributed at the time of issue, except Vol. VII, of which 1,500 were put in the hands of the Secretary of State, for sale at the cost of publication. Of these, a few remain at the date of the publication of this volume. The price is $1.50. To obtain copies, send postal or money order to the Secretary of State, State House, Columbus, Ohio. No other volumes can be obtained from this source.

The other volumes of this series can be procured only from second-hand book and library dealers.

Fourth Geological Survey.—Under the law, copies of these Bulletins can be bought at the office of the State Geologist at the cost of publication. Postal orders, money orders, checks, drafts, or currency must accompany orders. Stamps will not be received.

Bulletin 1—Oil and Gas	$ 0.65
Bulletin 2—Uses of Hydraulic Cements	0.30
Bulletin 3—Manufacture of Hydraulic Cements	Issue exhausted.
Bulletin 4—Lime Resources and Lime Industries	In press.
Bulletin 5—Lime-Sand Brick Industry	In press.
Bulletin 6—Bibliography of the Geology of Ohio, and Index to Publications of the Geological Survey of Ohio	———
Bulletin 7—Revised Nomenclature of the Ohio Geological publications	0.06
Bulletin 8—Salt Deposits and Salt Industry in Ohio	———

LAWS UNDER WHICH THE SURVEY OPERATES.

For the information of the public, the law under which the work of the Survey is prosecuted is herewith published:

Laws of Ohio, 1889, Vol. 86, p. 262.

(Senate Bill 409.)

AN ACT

To provide for the extension of the Geological Survey of the State.

Section 1. Be it enacted by the General Assembly of the State of Ohio, That the governor is hereby authorized to appoint a state geologist, whose duty it shall be to continue and extend the investigations already made into the geological structure and resources of the state. Said state geologist shall be appointed for a term of three years, but he may be removed for cause at any time, and a successor appointed in his stead; and the governor is authorized to fill any vacancy which may occur from any cause, at any time. The compensation of said state geologist shall be at the rate of two hundred dollars per month, for the time actually employed; and said geologist shall have power to employ such assistants as he may need; but in no event shall the salary of the geologist, pay of assistants, and expense of the department, exceed the amount of the expenditure authorized by the general assembly.

Section 2. It shall be the duty of said geologist to study, and determine as nearly as possible, the number and extent of the various formations of the state; to represent the same, from time to time, upon properly constructed maps and diagrams; to study the modes of occurrence and the distribution of the useful minerals and products of these formations; to determine the chemical composition and structure of the same; to investigate the soils and water supply of the state; and to give attention to the discoveries of coal, building stone, natural cement, petroleum, gas and other natural substances of use and value to the state. He may also collect and describe the fossils of the various geological formations of the state; but no expenditure shall be incurred under this head that is not expressly ordered and provided for by the general assembly.

Section 3. The said geologist shall make, on or before the first day in February of each year. a report to the governor, covering the work of the preceding year, and the report shall be transmitted to the general assembly, to be printed in the same manner as other public documents, or as shall be otherwise ordered.

Section 4. The salaries of the state geologist, and the assistants employed by him, together with the traveling and incidental expenses, shall be paid monthly, on presentation of properly itemized vouchers, signed by the governor, out of the state treasury, from the appropriation made for such purpose.

Section 5. There is hereby appropriated from the general revenue fund the sum of one thousand dollars annually, for the purpose above named.

Section 6. This act shall take effect and be in force from and after its passage.

NOAH H. ALBAUGH,
Speaker pro tem. of the House of Representatives.
THEODORE F. DAVIS,
President pro tem. of the Senate.

Passed April 12, 1889.

From the terms of the law, it was evidently intended to provide for the creation of a bureau of geology to which only a portion of the time of the State Geologist should be applied, as the annual appropriation made was much too small to provide the salary of a State Geologist continuously, without making any provisions for office expenses, assistance, etc. It was thought at that time that a few months' work per year would be sufficient to maintain the Survey abreast of geological developments.

The powers and duties of the State Geologist under this act were made so broad and general as to permit carrying on almost any work, so that no new legal provision was thought necessary in connection with re-opening the work of the Survey under the Fourth organization. The sum designated in Section 5 is not made a limiting condition of the law so that the Legislature may appropriate any other amount, at its discretion, for carrying on the work.

Acting under this law, the Legislature has made the following appropriations for geological work:

Designation of Legislature.	Year.	Amount Appropriated.
Seventy-Fourth..............	1900	$2,500 00
Seventy-Fourth..............	1901	$3,500 00
Seventy-Fifth................	1902	$5,000 00
Seventy-Fifth................	1903	$3,000 00
Seventy-Sixth................	1904	$2,800 00
Seventy-Sixth................	1905	$2,900 00
Seventy-Seventh.............	1906	$3,850 00*
Seventy Seventh.............	1907	$5,100 00

*And balance and receipts.

The law providing for the publication and distribution of reports is as follows:

Laws of Ohio, 1902, Vol. 95, p. 593.

(House Bill, 800).

AN ACT

To Provide for the Publication and Distribution of the Reports of the State Geologist.

Section 1. Be it enacted by the General Assembly of the state of Ohio, That whenever the state geologist shall have completed a bulletin upon any of the subjects upon which he is authorized to conduct investigation, he shall notify the state printing commission of this fact, and it shall be the duty of this commission to determine the number of copies which shall be printed, and the grade of paper, the kind of binding, and any other details incident to its proper publication.

Section 2. It shall be the duty of said commission to provide for the publication of said bulletin as soon as possible after the completion of the same. The issue shall consist of a minimum number of three thousand copies.

Of these, one thousand copies, after deducting 200 for the State Library, shall be distributed pro rata among the general assembly.

One thousand shall be distributed free by the state geologist in exchange with other surveys, and with individuals whose services have been used in the collection or preparation of the matter for the bulletins. Of this number not more than four hundred may be distributed during the first year after publication, and not more than fifty in any subsequent year.

One thousand copies shall be set aside for binding along with other bulletins from time to time, when a sufficient number of such bulletins have accumulated to make collectively a volume of from 800 to 1,000 pages. They shall be bound, lettered and numbered, to take their place in the series of volumes already published by the survey.

The distribution of the bound volume of the survey shall be in the hands of the state geologist; but the state library shall receive ten copies, each member of the general assembly one copy, with privilege to draw not to exceed two other copies on application, and public libraries in the state shall be supplied with one copy each. The volumes remaining after these demands have been met, may be distributed among the geological surveys and geological societies of the United States and of foreign countries in exchange for their publications.

Section 3. The board may, at its discretion, order the publication of extra copies in addition to the three thousand already provided for. These extra copies shall be placed in the hands of the state geologist. From these members of the general assembly may, on application, draw up to fifty (50) copies each. Those remaining shall be placed on sale at a price equal to the net cost of printing and binding, which price is to be established by the state supervisor of public printing. The proceeds of such sales shall be accounted for and paid into the state treasury, and the state geologist shall be required by the commission to give suitable bond for the security of the funds thus passing through his hands. The proceeds of such sales shall be credited to the account of the geological survey and shall be used for the prosecution of the further work of the survey without distinction from other funds which the general assembly from time to time appropriates for the survey.

Section 4. The cost of printing, illustrating, electrotyping, binding, et cetera, of said bulletins and said volumes, shall be paid from the general appropriation for state printing.

Section 5. This act shall take effect from and after its passage.

W. S. McKINNON,
Speaker of the House of Representatives.
F. B. ARCHER,
President of the Senate.

Passed May 12, 1902.

THE SURVEY IN ITS RELATIONS TO THE PUBLIC.

The usefulness of the Survey is not limited to the preparation of formal reports in important topics. There is a constant and insistent desire on the part of the people to use it as a technical bureau for free advice in all matters affecting the geology or mineral industries of the State. A very considerable correspondence comes in, increasing rather than decreasing in amount, and asking specific and particular questions on points in local geology.

The volume of this correspondence has made it necessary to adopt a uniform method of dealing with these requests. Not all of them can be granted, but some can and should be answered. There is a certain element of justice in the people demanding such information, from the fact that the geological reports issued in former years were not so distributed as to make them accessible to the average man or community today. The cases commonly covered by correspondence may be classified as follows:

1st. Requests for information covered by previous publications.—This is furnished where the time required for copying the answer is not too large. Where the portion desired cannot be copied, the enquirer is told in what volume and page it occurs and advised how to proceed to get access to a copy of the report.

2d. Requests for identification of minerals and fossils.—This is done, where possible. As a rule, the minerals and fossils are simple and familiar forms, which can be answered at once. In occasional cases, a critical knowledge is required and time for investigation is necessary. Each assistant is expected to co-operate with the State Geologist in answering inquiries concerning his field.

3d. Requests from private individuals for analyses of minerals and ores, and tests to establish their commercial value.—Such requests are frequent. They cannot be granted, however, except in rare instances. Such work should be sent to a commercial chemical laboratory. The position has been taken that the Geological Survey is in no sense a chemical laboratory and testing station, to which the people may turn for free analytical work. Whatever work of this sort is done, is done on the initiative of the Survey and not at the solicitation of an interested party.

The greatest misapprehension in the public mind regarding the Survey is on this point. Requests for State aid in determining the value of private mineral resources, ranging from an assay worth a dollar, up to drilling a test well costing several thousand dollars, represent extreme cases. At present there is no warrant for the Survey making private tests, even where the applicant is entirely willing to pay for the service. In many cases individuals would prefer the report of a State chemist or State geologist to that of any private expert, at equal cost, because of the prestige which such a report would carry. But it is a matter of doubt whether it will ever be the function of the Survey to enter into commercial work of this character; it certainly will not be unless explicit legal provisions for it are made.

4th. Requests from a number of persons representing a diversity of interests, who jointly ask the Survey to examine into and publicly report upon some matter of local public concern.—Such cases are not common. It is not always easy to determine whether such propositions are really actuated by public interest or not. Each case must be judged on its merits. The Survey will often be prevented from taking up such investigations by the lack of available funds, while otherwise the work would be attempted.

The reputed discovery of gold is one of the most prolific sources of such calls for State examination. It usually seems wise and proper to spend a small sum in preventing an unfounded rumor from gaining acceptance in the public mind, before it leads to large losses, and unnecessary excitement. The duty of dispelling illusions of this sort cannot be considered an agreeable part of the work of the Survey, but it is nevertheless of very direct benefit to the people of the State.

SALT DEPOSITS AND THE SALT INDUSTRY IN OHIO

BY

JOHN ADAMS BOWNOCKER, D. Sc.

LETTER OF TRANSMITTAL

Professor Edward Orton, Jr., State Geologist:

DEAR SIR:—I transmit herewith my report on Salt Deposits and the Salt Industry in Ohio.

Respectfully submitted,

J. A. BOWNOCKER.

May 1st, 1906.

TABLE OF CONTENTS

PAGE.

I. Introduction 9

II. The Beginning 9

III. Expansion of the Industry 12

Columbiana County 13

Tuscarawas County 13

Morgan County 13

Guernsey County 15

Hocking Valley 15

IV. Meigs County 15

Early History 15

Salt Production in Ohio and the United States . 17

By-Products 18

Existing Furnaces 18

Manufacture of Salt 20

The Buckeye Salt Company 22

The Coal Ridge Works 23

The Pomeroy Salt Works 23

The Syracuse Salt, Bromine and Calcium Works . 23

The Pomeroy Salt Association 23

The Manufacture of Bromine 24

The Manufacture of Calcium Chloride . . . 24

Fuel 24

Geological Considerations 25

Chemical Examination 27

V. Northeastern Ohio 28

The Wadsworth Salt Company 28

Vacuum Pans 30

Drying, Screening and Marketing . . . 30

Ohio Salt Company 32

Salt Manufacture 32

The Grainers 33

Fuel 34

Market for Salt 34

The Union Salt Company 34

The Cleveland Salt Company 36

The Colonial Salt Company 37

Chemical Examination 38

VI. Limits of the Field 39

VII. Appendix 41

ILLUSTRATIONS.

PAGE.

Map of Eastern Ohio.. 8

Exterior View—Old Salt Works at Durant, Ohio.......................... 14

Interior View—Old-fashioned Kettle Furnace at Durant, Ohio.............. 16

Bromine Plant at Pomeroy... 19

Exterior View of a Modern Salt Works at Wadsworth, Ohio................ 29

Exterior View of a Modern Salt Works at Rittman, Ohio.................... 31

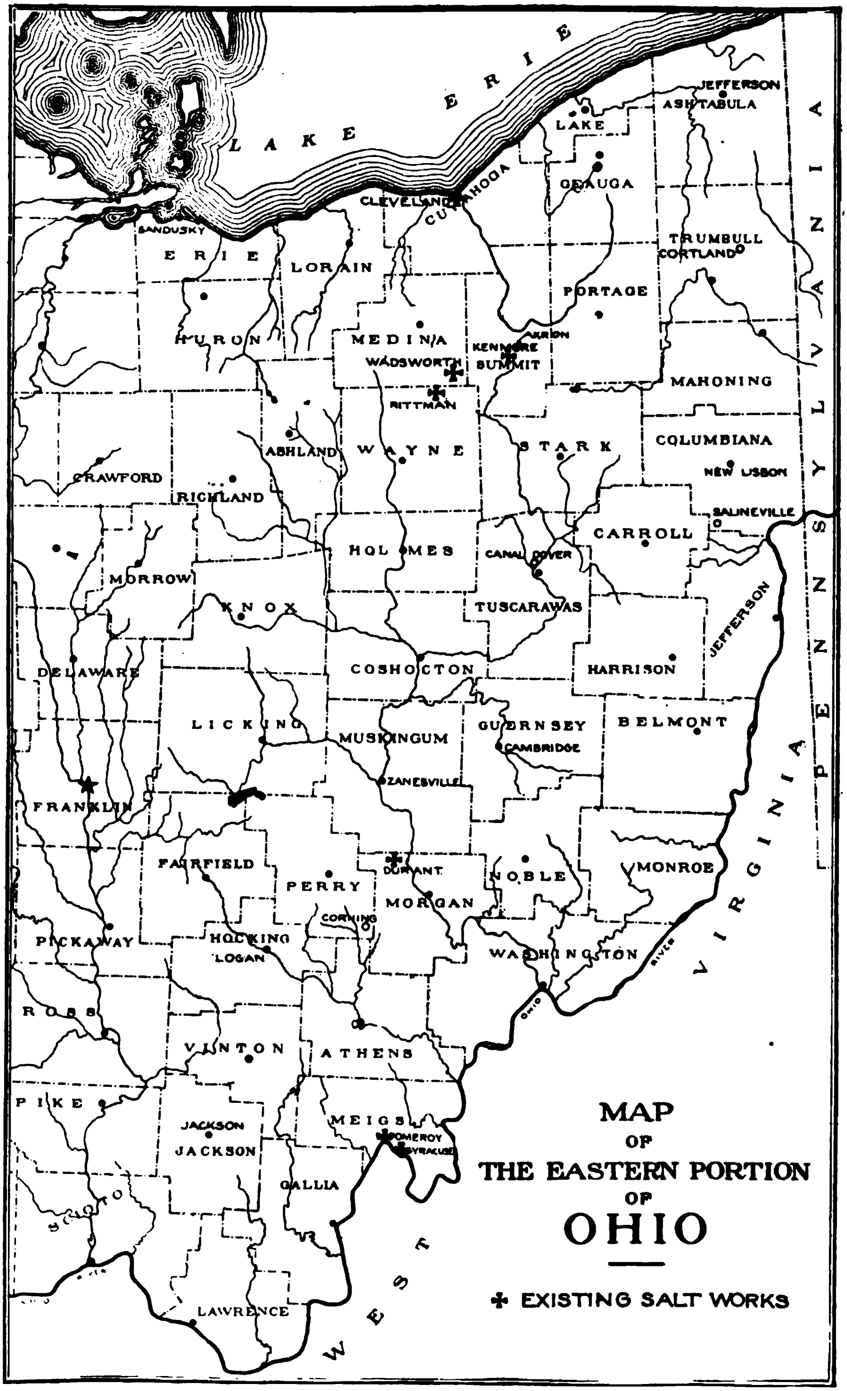

Figure 1.—Map of Eastern Ohio.

SALT DEPOSITS AND THE SALT INDUSTRY IN OHIO.

I. INTRODUCTION

The first settlers of Ohio found salt one of the most expensive of necessities. At that time not a pound was produced in the territory, and in consequence residents were compelled to rely on the production east of the Appalachian mountains. The salt had to be transported on horseback or in wagons across the mountains, and hence was expensive. From 1788 to 1800 the price ranged from four to eight dollars per bushel,[1] and many residents felt that the absence of a local supply and the resulting high price would prove a serious handicap to the development of the country. When, however, the valleys of the southeastern part of the territory began to be explored, salt springs were found, and naturally the discoverers were not slow in taking advantage of these brines.

II. THE BEGINNING

Probably the first attempt to make salt on land now forming part of the state was in 1798.[2] The locality was the old Scioto salt works on the banks of Salt creek in what is now Jackson county. These salt springs were well known to the buffalo and other wild animals, long before the white man discovered them. Buffaloes came in herds, forming well beaten paths, recognizable as late at least as 1837.[3] Regular pilgrimages to the licks were made by these animals until they were driven from the territory. That they were loth to abandon so favored a spot is shown by the fact that the last buffalo seen native in Ohio was near these licks, the date being 1802.[4]

From earth works near the licks it has been thought that the Mound Builders appreciated the locality as well as did the lower animals. Later the spot was a favorite with the Indians; the men killed the game which came for brine, while their squaws busied themselves making a little salt. Wells were not dug, the Indians simply taking the brackish water from the creek at low water stage and evaporating it. The last of their old salt pans was blasted out in 1899.[5] Pilgrimages were made to the licks each summer by the Indians until about 1815.

The date of the white man's discovery of the licks is not known, but it was probably early in the eighteenth century by Canadian fur traders.

---

[1] The bushel contained at first 80 pounds; later 50 pounds.

[2] *Am. Jour. Sci. and Arts*, vol. 24, p. 46.

[3] Whittesley quoted in *History of Jackson County, Ohio*. p. 11.

[4] Williams, *History of Jackson County, Ohio*. p. 14.

[5] Ibid, p. 31.

The Virginia colonists knew of them at least as early as 1755. In 1795 a company of white salt boilers settled on the licks, and the camp is said to have grown quite large before the close of the century.[1]

Officials of the federal government soon learned of the licks, and prompt action was taken to prevent their falling into the hands of parties who might make a monopoly of them. Thus in 1796 Congress passed an act providing for the sale of lands northwest of the Ohio river, but expressly reserved for future disposal the area containing these licks. No arrangement was made, however, for operating the licks, but this was done a few years later when the territory became a state.

Early wells at these licks were quite shallow, varying from 20 to 30 feet in depth. The brine was correspondingly weak, from 600 to 800 gallons being necessary to make a bushel of salt. The product had a dark color and was otherwise inferior, but it was so much better than none that it commanded a high price.

Other pioneer wells were located on Salt creek about nine miles southeast of Zanesville, on Duck creek in Noble and Washington counties, and in the valley of the Muskingum. In all of these the salt industry started near the beginning of the nineteenth century, probably about the time of the state's admission into the Union. It is worthy of mention in this connection that several of these wells demonstrated the presence of petroleum and natural gas, though advantage was not taken of the discovery.

April 30, 1802, Congress passed the enabling act preparatory to Ohio becoming a state, the act providing, among other things, that an area of 36 square miles containing the Scioto salt springs shall be granted to the state for the use of its inhabitants. The legislature was empowered to frame regulations governing the use of the licks. The whole object seems to have been to prevent individuals or companies from obtaining a monopoly of them.

The first state legislature met March 1st, 1803, and soon considered leasing the salt licks. An act became a law April 13, 1803, which provided:

(1) That the state shall keep an agent for one year at the licks, who shall issue license to salt makers, collect the rent, study the geology of the region, and in other ways look after the state's interests.

(2) That no person or company shall use more than 120 kettles.

(3) That persons making salt shall pay to the agent three cents per gallon, payable quarterly, on the capacity of the plant.

April 14, 1803, the two houses met together and elected James Denny agent as provided for in the act referred to above.

In January, 1804, a second act relating to the licks was passed. This described more specifically the lots that might be rented for salt purposes, fixed the rent at four cents per gallon, and required the agent to inspect the salt. The rent was changed February 20th, 1805, to two cents per gallon; February 13, 1808, to one cent per gallon; and January 19, 1810, to one-half cent per gallon.

---

[1] Ibid, p. 52.

The quantity of salt produced did not meet the expectations of the legislators, and an act was passed February 17th, 1812, to encourage deeper drilling. Similar acts were passed in 1813, 1814, and 1815, the last requiring a depth of 350 feet. It is reported that the honest driller went 100 feet deeper than the law required. A stronger brine was found, but the quantity was not ample.

According to Hildreth, the region was at its zenith of activity from 1806 to 1808, when twenty furnaces were in action, each averaging from fifty to seventy bushels of salt per week. When stronger brines were found on the Kanawha and other localities the Scioto licks were at a disadvantage, the result being that the industry languished and was finally abandoned.

In 1818 the legislature announced that the salt licks were no longer a success, and asked Congress to permit the state to sell the land. This request was not granted until the closing days of 1824. In June, 1826, a three days' public sale was held and all lands not sold during that time were disposed of privately.

The act of Congress which provided that the Scioto salt licks should be reserved by the state also provided that where other licks were found, the enclosing land, 640 acres in area, should in a similar manner be retained by the state. Under this provision it appears that one tract was reserved on Salt creek in Muskingum county, and another one in Delaware county. These three localities were the only ones in Ohio known at that time where salt licks existed. These tracts also seem to have been disposed of by the state in 1826.[1]

It is said that as late as 1808 the wells penetrated the mantle rock only. The first effort to secure brine in bed rock is reported to have been made in the valley of the Great Kanawha, near Charleston. At first these wells reached depths ranging from 70 to 80 feet, but later extended to 350 feet. The brine was found to increase in strength with the depth, a discovery of great importance. In some places, however, deep wells were not a success, for example those of the Scioto salt licks.

In 1817 drilling began in the Muskingum valley, the first well having been located a few miles below Zanesville. Two years later a well was drilled in this town, water furnishing the power. These wells, however, seem never to have been profitable. Farther down the valley results were more favorable, wells existing at short intervals for a distance of 30 miles. Finding that the strength of brine increased with the depth, wells were drilled 850 feet deep, when a brine of such strength was found that a gallon made one pound of salt. By 1833 this valley is reported to have produced between 300,000 and 400,000 bushels per year.

---

[1] *Am. Jour. Sci. and Arts.*, vol. 24, p. 26.

Among other places producing considerable salt at about that time may be mentioned Yellow creek, Columbiana county, the valley of Hocking river in Athens county, and Leading creek, in Meigs county.

Drilling in those days was a laborious process. A hole from four to six feet in diameter was dug through the surface material into the bed rock. Into this hole, called the "head," was placed a hollow sycamore log known as the "gum," or in its stead a rectangular tube constructed of planks, to exclude surface water. At the lower end of this drilling began. In early years the spring pole was used, men furnishing the power. This was succeeded by the treadle, a horse doing the work. In still later years steam was used. During the first part of the century work continued as a rule day and night, the men working in shifts or tours of six hours each. Progress was very slow. It is stated that six feet were considered a large day's work. Caving was usually prevented by the insertion of a copper tube, though it does not appear that long strings of this tubing were used.

The salt was made by evaporating the brine in large iron kettles, each holding form 60 to 80 gallons. These were set in a row over a flue which terminated at one end in a chimney. The fuel was wood taken from the adjacent forests.

The brine was pumped from the wells into a tank constructed of wood, and connected by tubes made of the same material with the kettles. After having been boiled for a time the brine was dipped into a cistern where it was allowed to cool and settle. In this manner such material as had been mixed with the water in a mechanical way was deposited, and also oxide of iron, which was at first dissolved in the brine, but was made insoluble by boiling.

When the settling had been completed the brine was again conveyed by wooden tubes to certain ones of the row of kettles, known as "grainers." Into these was thrown a small quantity of clay which served as a nucleus for any remaining impurities, the whole being skimmed from the surface of the kettles. Beef's blood soon took the place of the clay, and this crude method is still followed in one small plant.

When salt had been precipitated in the kettles by boiling, it was thrown into "drainers," and the mother liquor, containing principally calcium chloride, drained off. The salt was then dumped into a shed known as the "salt house," and the drying completed. It was then barreled and marketed.

III. EXPANSION OF THE INDUSTRY

The industry grew rapidly and soon extended far beyond the areas already mentioned. The furnaces have long been abandoned, even the location of many having been forgotten. Under such conditions little more can be now done than to mention the principal localities.

Columbiana County.—If this was not the northernmost county producing salt, it certainly was the most northern important producer. The village Salineville, situated in the southeastern corner, was an early center of importance, and the same is true of the valley of Little Beaver on the east side of the county. A number of wells formerly existed in the valley of the Ohio between East Liverpool and Wellsville. A small quantity of salt was still made in this locality in 1876. In 1888 only one salt furnace was in operation in the county. This was located a few miles east of Lisbon, and was owned and operated by the New Lisbon Salt Company. The plant was built in 1868, and had a daily capacity of 65 barrels. The brine had a density of 10° B., and was supplied by two wells, one having a depth of 630 feet and the other 687 feet, the well heads being at the horizon of the Freeport coals. The bittern waters were used either as a fertilizer, or were allowed to waste.[1] The salt was sold principally in the vicinity. The plant was abandoned about fifteen years ago.

Tuscarawas County.—The salt industry in this county began in 1865, the first furnace having been located at Canal Dover. The wells started at the horizon of the Kittanning coals, and were about 900 feet deep. The brine had a density of 10° B., seven barrels having been necessary to produce one of salt.

Some bromine was found in the brine. After the salt had been precipitated, the remaining liquid was evaporated to a density of 45°B, and then distilled. One hundred and eighty gallons of this bittern yielded from fourteen to fifteen pounds of bromine.[2] Iodine was also present, but was not separated, owing to the expense.

In 1888 there were three furnaces in this vicinity having a combined daily capacity of from 180 to 200 barrels of salt.[3] The latter was handled by the Tuscarawas Valley Salt Company, the market being principally in the adjacent territory. As the price of salt fell lower and lower the operators found the profits growing smaller and smaller, until the industry could no longer be conducted with profit. Finally, about 1890 the furnaces were closed.

Morgan County.—The valley of the Muskingum which crosses the county from north to south is one of the oldest producers in the state. It appears that several furnaces were in operation as early at least as 1825. The brines, however, were weak, having a density of only 7½° B. Moreover, when the supply of wood became inadequate and coal was necessary, the furnaces were at a further disadvantage because the coal had to be transported some distance, thus adding to the expense. Since the Civil War the industry has declined until at present (1905) one furnace alone remains.

---

[1] *Geol. Sur. of Ohio*, vol. VI, p. 654.
[2] *Geol. Sur. of Ohio*, vol. III, p. 84.
[3] Vol. VI. p. 656.

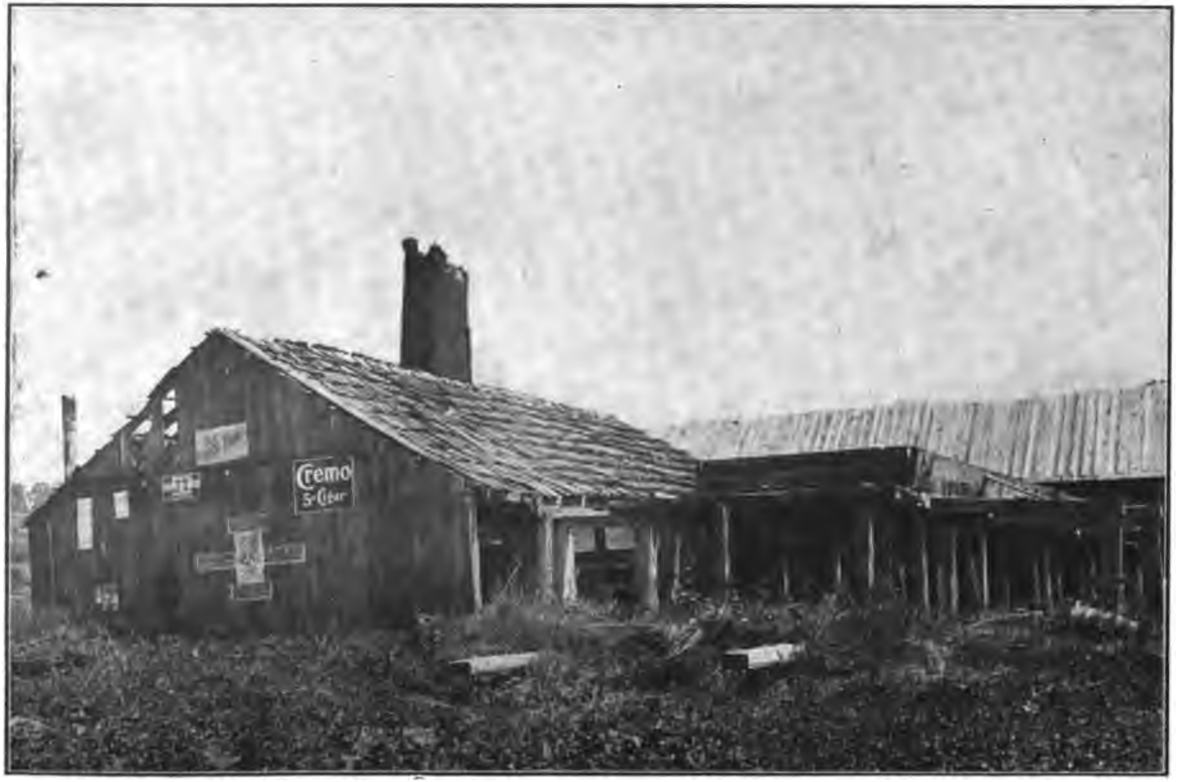

Figure 2.—Exterior view of an old salt works at Durant, Ohio.

This is located at Durant on the Muskingum river in the extreme northern part of the county. As late as the summer of 1903 the furnace was of the type of that a half century ago, and was known as the Big Bloom Salt Works. The brine was evaporated in iron kettles, 31 in number, each holding 90 gallons (see illustration). Beef's blood was the clarifying agent, and in other respects the process was similar to that of the pioneer days of the salt industry. The capacity of the plant was reported at 30 barrels of salt per day.

When this locality was revisited in August, 1904, the old plant had disappeared, but a new one stood near by. It was operated by the Muskingum River Salt and Coal Company, the capacity being 20 barrels per day. The plant had two vats, each 60x20x6 feet, and two grainers each 16x10x2½. The brine is evaporated with live steam, the fuel being coal. Beef's blood is still used as the clarifying agent, this being the only plant in Ohio retaining this primitive method. The brine which is obtained in the Salt sand is supplied by two wells having depths approximating 670 feet. The well heads are about 50 feet above the Middle Kittanning coal.

Zanesville is the principal market for the salt, shipment being by river.

Hocking Valley.—In early days a number of furnaces were in operation in this and tributary valleys, especially that of Sunday creek. Strong brines were found from 450 to 500 feet below the Middle Kittanning coal. As late as 1877 salt was made at McCuneville on the Shawnee branch of the Baltimore and Ohio railroad, and at Salina on the Hocking canal.[1]

Guernsey County.—In early days a number of salt furnaces existed in this county, but the quantity of salt produced was always small, and was consumed almost wholly in the adjacent territory. As late as 1887 one furnace was in operation. This was located about eight miles north of Cambridge, and was constructed in 1859. The capacity of the plant was less than ten barrels per day. The brine, having a density of 5° B., was supplied by a well 450 feet in depth. The works were abandoned about 1890.

IV. MEIGS COUNTY

Early History.—Meigs county is by far the most important salt producer in southeastern Ohio. In fact, it is probable that it has produced more than all others in that section of the state combined. Moreover, its furnaces are still active, though the yield is much smaller than in former years.

Salt making in Meigs county began on Leading creek, a short distance below Middleport. The date of the beginning is not known, but

---

[1] Vol. III, p. 115.

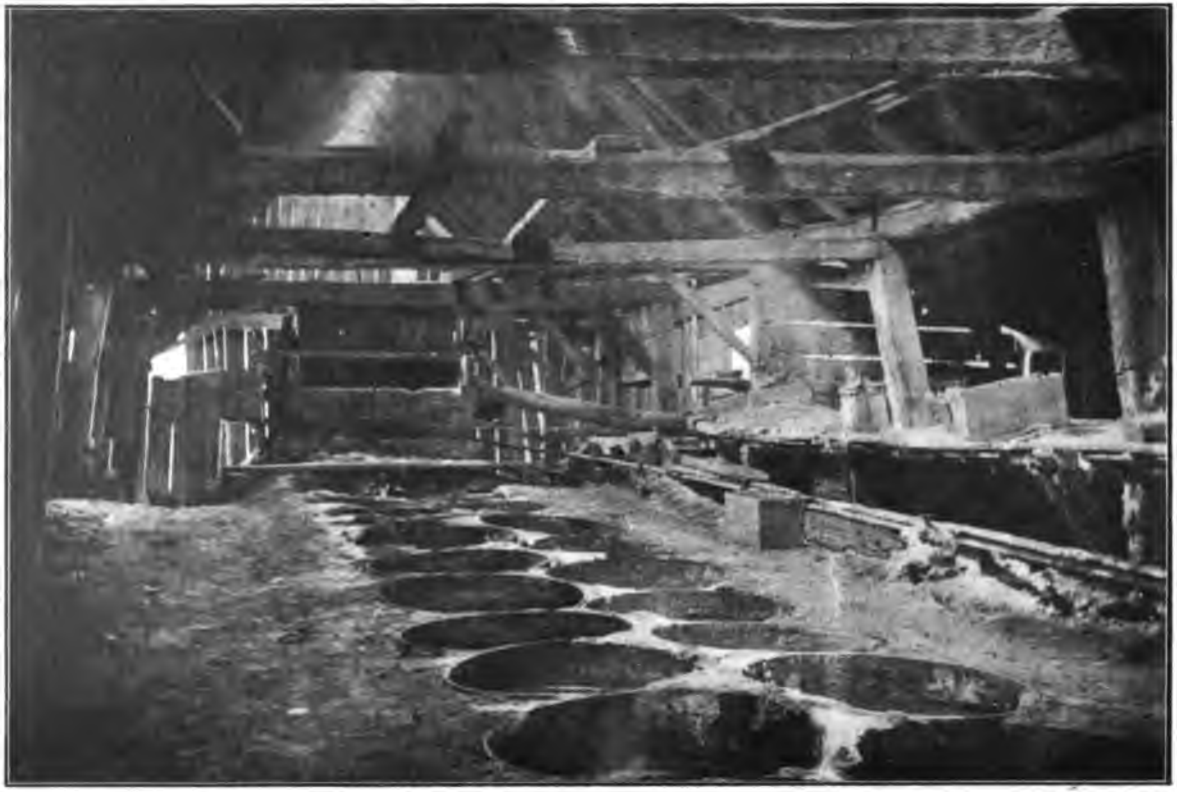

Figure 3.—Interior view of the old kettle furnace at Durant, Ohio.

was prior to 1847. The brine was evaporated in kettles, and the production small. These furnaces were abandoned many years ago.

About the year 1850 the industry began at Pomeroy. Pans were used from the start to evaporate the brine, the present process being substantially that introduced more than half a century ago. The possession of relatively strong brines, fuel in the adjacent hills, and river transportation made the industry profitable; the result being a rapid expansion of the industry, and Pomeroy became one of the best known salt centers in the country.

THE SALT PRODUCTION OF OHIO FROM 1882 COMPARED WITH THAT OF THE UNITED STATES.

[Barrels of 280 pounds.]

Year.	Ohio.	United States.	Ohio's percentage of total production,	Rank of state.
1882	400,000	6,412,273	6.2	3
1883	350,000	6,192,231	5.6	3
1884	320,000	6,514,937	4.8	3
1885	306,847	7,038,653	4.3	3
1886	400,000	7,707,081	5.1	3
1887	365,000	8,003,962	4.5	3
1888	380,000	8,005,881	4.7	4
1889	250,000	8,005,565	3.1	6
1890	231,303	8,876,991	2.6	6
1891	....	9,987,945	....	..
1892	....	11,698,890	....	..
1893	543,963	11,897,208	4.5	4
1894	528,996	12,968,417	4.0	4
1985	781,000	13,669,649	5.7	4
1896	1,662,358	13,850,726	12.0	3
1897	1,575,414	15,973,202	9.7	3
1898	1,682,247	17,612,634	9.5	4
1899	1,460,516	19,708,614	7.4	4
1900	1,425,283	20,869,342	6.8	4
1901	1,153,535	20,566,661	5.6	4
1902	2,109,987	23,849,221	8.9	4
1903	2,798,899	18,968,089	14.7	3
1904	2,455,828	22,030,002	12	3

The maximum number of furnaces on the Ohio side of the river is reported to have been 13 during or shortly after the Civil War. From that time the number steadily decreased; in 1887 it was seven; in 1905, five. The cause of the decline has been the immense expansion of the industry in New York and Michigan, and later in northeastern Ohio. These centers are relatively at a disadvantage so far as fuel is concerned, but this is more than offset by the saturated brine. So cheap is salt now made that only those plants most favorably situated survive. Every furnace in southeastern Ohio, except five at Pomeroy and vicinity, and one at Durant, has closed, and the near future may find the number still smaller.

The one cause for this decline has been the drop in the price of salt. About the close of the Civil War this salt sold for $2.50 per barrel.[1] In July, 1897, it sold for 47 cents, and has been marketed in small lots for 40 cents. This price included a barrel, the manufacture of which cost about 25 cents. In other words, 280 pounds of salt have sold for 15 cents. In July, 1903, the price was 65 cents, and in September, 1905, 70 cents.

A new factor appeared in 1899; this was the United Salt Company, or as it was popularly known, the "Salt Trust." It closed one or two plants and arranged to take the production of the others (with one exception) at an agreed price. The result was a marked advance, salt commanding $1.10 per barrel in the closing months of 1900. In the opening of 1901 the trust went into the hands of a receiver and the artificial price fell. By May, 1902, salt had dropped to 58 cents per barrel.

Much of the salt made in this locality during the last 25 years has been sold to J. B. Speed and Company, who shipped it in barges to Louisville, repacked and marketed it. After the collapse of the United Salt Company, the Pomeroy Salt Association was formed. This is merely a selling agency. The principal market for the Pomeroy salt is in the Lower Ohio and Mississippi valleys.

By-Products.—Were it not for the by-products, not a pound of salt would now be produced in this territory. It is claimed, and seems true, that the salt alone is made at a financial loss, but the bromine and calcium chloride have yielded sufficient returns to keep a small number of furnaces active.

Bromine was first made in this locality in 1868 at the Dabney salt works, long since abandoned.[2] The industry flourished from the start and soon made Pomeroy the best known bromine center in the United States. It is claimed that at one time the material commanded $10 per pound. By 1887 it had dropped to 33 cents, was selling at 22 cents in July, 1903, and about 15 cents in September, 1905. The principal cause of the decline has been the large yield of the Michigan salt fields. With the decline in the salt industry at Pomeroy there has been, of course, a proportional decrease in the output of bromine.

The writer has been unable to learn the date of the beginning of the calcium chloride industry in this territory. Mr. W. J. Root reports a large production in 1888, and hence the start antedates that period.[3] The earliest year that the writer has heard mentioned is 1884, but the beginning seems to have antedated that period.

Existing Furnaces.—Koehler's Excelsior Salt Works are located in the east end of Pomeroy where they were established in 1860. Since that time the furnace has been in operation, with the exception of short

---

[1] 280 pounds.
[2] *Geol. Sur. of Ohio*, vol. VI, p. 668.
[3] Vol. VI, p. 669.

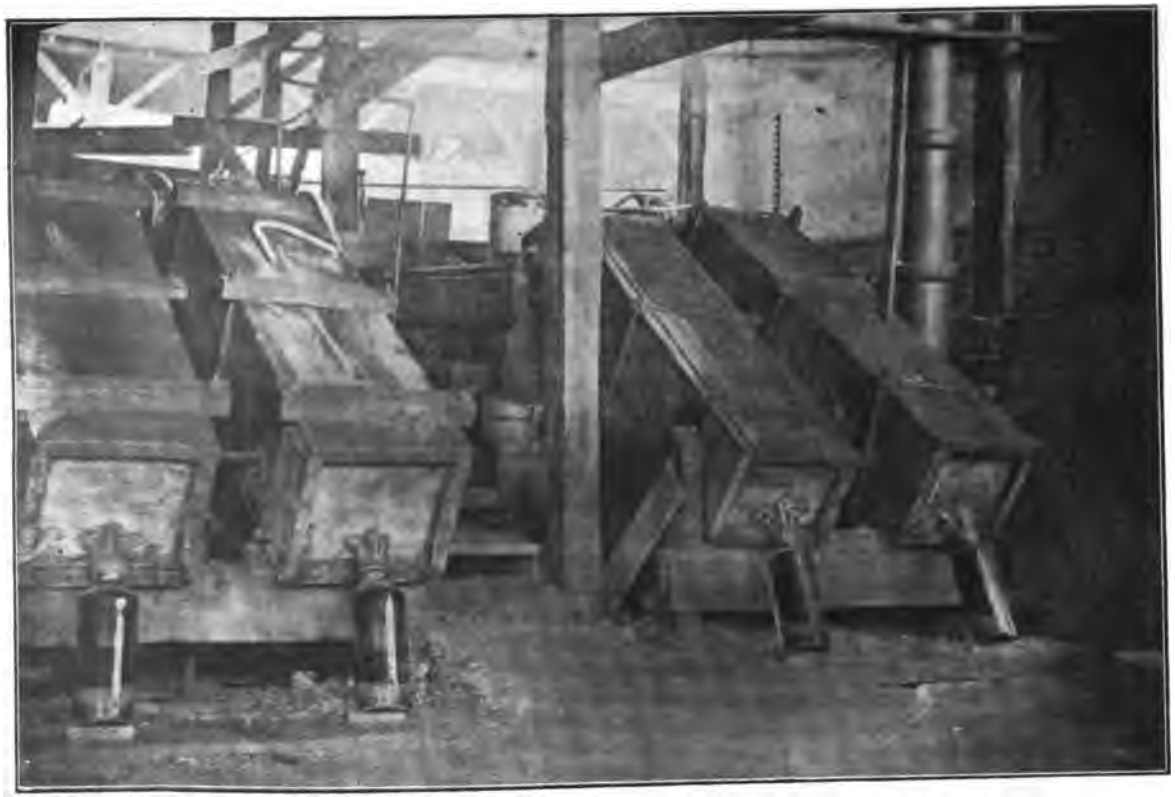

Figure 4.—Bromine plant at Pomeroy.

periods when closed for repairs. In 1884 the works came into the possession of B. Koehler, and are still owned and operated by members of his family. The plant has a daily capacity of 280 barrels of salt. Two bromine stills are operated, but the bittern waters containing the calcium chloride are sold to the Eureka Calcium Works, located on an adjacent lot. Four wells having depths ranging from 1,100 to 1,200 feet supply the brine. The wells were cased part way, when they were drilled, and this still remains in part in them. Three inch tubing is used in pumping. The company counts on one pound of bromine to two barrels of salt. On the average 40 people are employed.

The Buckeye Salt Company was established in 1865 and has been in operation ever since with occasional periods of enforced idleness for repairs. Mr. Charles McQuigg, the manager of the company, places the capacity of the plant at 350 barrels per day. Five wells are required to supply the necessary brine. The wells have depths ranging from 1,089 to 1,590 feet, the latter reaching the Berea grit. Like the Excelsior, the Buckeye Company disposes of its bittern waters to the Eureka Calcium Works. Fifty-five pounds of bromine are reported from 100 barrels of salt. The company mines its own coal, thus securing fuel at the minimum expense. In all 80 people are employed.

The Coal Ridge furnaces, located in the extreme east end of Pomeroy, were chartered in 1852, and began making salt two years later. The production ranges usually from 200 to 250 barrels per day. For fuel, run of mine coal is used, the company doing its own mining. Bromine and calcium plants are maintained, so that the company makes the most of the by-products.

The Pomeroy Salt Works are located near the western limits of Pomeroy, and were constructed about 1852. The company still exhibits a diploma for the best barrel of salt displayed at the state fair in 1855. Brine is supplied by three wells, ranging from 1,000 to 1,100 feet in depth. Bromine and calcium plants are maintained. The production of salt is about 225 barrels per day.

The Syracuse Salt, Bromine and Calcium Works began making salt in 1868. In 1904 the plant was practically rebuilt. The four wells are about 1,300 feet deep, the well heads starting 95 feet above the Pomeroy or No. 8 coal. About 200 barrels of salt per day are made. The company operates its own bromine and calcium plants. Run of mine coal is used for fuel.

Manufacture of Salt.—The process is quite similar in the plants now in operation. For convenience the methods of the Excelsior works will be described somewhat in detail, and then such modifications as are in use in the few remaining plants will be noted.

The brine is pumped from the wells into wooden tanks, of which there are two. These measure approximately, the one 70x12x6½ feet, and the other 38x12x6½ feet. When first run into the tanks the water is clear, but soon changes to a light red, owing to the oxidation of the iron contained in the brine. These tanks are intended simply to collect the brine, any physical or chemical changes taking place being merely incidental.

From these tanks the brine is run into the heaters—long, shallow wooden boxes that are traversed by a copper pipe through which steam passes. This is the beginning of the evaporation, though in this stage the heat is sufficient simply to make the brine lukewarm.

The brine is run from the heaters into the furnace, entering the latter directly over the fire. The furnace is divided into four sections and each consists either of sheet or cast iron pans of variable length. The first section, consisting of ten cast iron pans, each ten feet long and three feet wide, lies directly over the fire. The pans are bolted together so that they really make one with numerous partitions. The second section duplicates the first. The third section consists of ten cast iron pans, each 8 feet long and 3 feet wide, all bolted together. The fourth section consists of one sheet iron pan, 35 feet long and 8 feet wide.

All pans are covered with a steam chest, consisting simply of a wooden box. Steam collected in this is used in evaporating the brine after it leaves the furnace.

From the furnace the brine is run into mud settlers, two in number. These are wooden boxes having dimensions of 160x8x4 feet. Each box or settler has a partition extending through it lengthwise, and each division of this has a copper steam pipe running through it, connecting at one end with the steam chest lying over the furnace, referred to in the preceding paragraph. Iron, clay and other impurities contained in the brine collect in these boxes, precipitation being aided by the addition of a small quantity of alum. That the impurities contained are few is shown by the fact that the boxes have to be cleaned only once a year.

From the mud settlers the brine is run into the draw settlers. The latter have the same length as the former, but are 10 feet wide and are not divided by a partition. Each is traversed by a steam pipe. These settlers serve to precipitate any impurities that escaped the mud settler; they also assist in evaporating the brine, some of the salt precipitating in them. Salt formed in this place has a light red color, due to the presence of a small quantity of iron, and is known in the market as red salt. It is used for glazing clay-wares. The salt is taken from these settlers once a year.

Each settler contains sufficient brine to supply the plant twenty-four hours. While the brine is collecting in one it is running from the other into the grainers.

The latter, seven in number, resemble the draw settlers, but are shallower, measuring only about two feet in depth. Each grainer is traversed lengthwise by three copper steam pipes. The evaporation is completed in the grainers, the salt accumulating on the bottom; the bittern waters, containing the bromine and calcium chloride, remaining suspended over the salt.

This company makes three grades of salt, of No 1 quality—fine, medium and coarse. The formation of crystals requires time; hence the lower the heat and slower the evaporation, the larger the salt grains. Production of small crystals or grains is aided by the addition of a small quantity of tallow or butter to the brine in the grainers. This forms a film on the brine, preventing the formation of thin sheets of salt on the surface and thus checking the evaporation. The result is a finer grained salt than when the grease is not used.

The salt is lifted by hand shovels from the grainers once each day and piled on boards which extend lengthwise over the middle of the grainers. After drying in this position over night, the salt is hauled in wheelbarrows to the salt house where drying is continued for approximately a week. The salt is then barreled and marketed.

The salt in the first six grainers is of No. 1 quality; that in the seventh is inferior, owing to the presence of some of the constituents of the bittern waters, and is sold for glazing and fertilizing purposes.

The Buckeye Salt Company.—This company has shown a commendable spirit by endeavoring to improve the process of salt manufacture. These efforts have required the expenditure of both time and money and have not always been successful. However, the results are on the whole favorable. Mr. Edward McQuigg is the manager of this company, and to him belongs the credit for the improvements.

When this plant was visited in July, 1903, furnace steam was used in the settlers only. Boilers supplied live steam for the grainers, the pressure in the former ranging from 40 to 60 pounds, and in the grainers about 20 pounds. Fresh water only was used in the boilers. The grainers were filled at intervals of twelve hours, but the salt was lifted or shoveled from them once only in twenty-four hours. As would be expected, the grainers with their higher heat produced a much larger body of salt per day than those heated by steam from the furnace, though the expense of the boilers and additional fuel offset the increased production of salt. This company was using alum in the settlers to clarify the brine, but expected to discontinue this, substituting lime. The change results from a belief that alum liberates some of the bromine.

The use of live or boiler steam to evaporate the brine was discontinued in October, 1904, the process having proven too expensive. The steam from the furnace pans is now collected in a wooden box known as the "equalizer." From this the steam is conducted to the six grainers, thus supplying equal heat to all, and in consequence producing an even grained salt.

The grainers are lined with tiling. A trial was made of cement, three inches on the bottom and four inches on the sides, but the experiment was unsuccessful, the cement cracking.

In the summer of 1904 the grainers were equipped with self-rakes. These consist of endless chains of brass, one on each side of each grainer. Cross pieces of wood covered with brass are attached to the chains. The latter are slowly turned by steam power, dragging the cross pieces along the bottom of the grainers and removing the salt as fast as formed.

The rakes drop the salt on a slowly moving belt, fourteen inches wide, which conveys it into the salt house. The self-rakes enable the company to dispense with ten salt lifters.

The salt is shipped largely in bulk in barges; also in barrels of 280 and 350 pounds, and sacks of 100 to 150 pounds.

Run of mine coal is used for fuel. It is claimed that one bushel produces one and one quarter bushels of salt, the latter bushel weighing fifty pounds.

The Coal Ridge Works.—Here they clarify the brine with lime and alum, sometimes the latter only. About one pound of alum is used to thirteen barrels of salt and one barrel of lime to 2,500 barrels of salt. The latter is left to dry about twenty hours on boards over the grainers, is then loaded in a small car and hauled by steam power to the salt house. In other respects the process is similar to that of the Excelsior Company.

The Pomeroy Salt Works.—This company uses the same process as the Excelsior and and Coal Ridge furnaces. Salt of coarse, medium and fine grain is made.

The Syracuse Salt, Bromine and Calcium Works.—This company employs the same general process that has been used in the Pomeroy field for half a century. A small quantity of lime is used in the furnaces and alum in the draw settlers. Salt is removed by hand. Run of mine coal is used for fuel.

The Pomeroy Salt Association Company.—This company in 1905 begun constructing a plant which is in many ways a marked departure from existing works.

First the brine will be lifted from the wells by compressed air and then run through crushed rock filters. From these the brine will be conveyed into an "evaporator" consisting of an iron cylinder containing steam coils. Here it will be boiled and then run into settlers and finally into the grainers. The steam will be conducted from the "evaporator" to the settlers and perhaps also to the grainers. The steam pressure in the "evaporator" will be low, not much more than is found in existing furnaces.

Two, perhaps three, settlers will be used, each measuring 176x12x2 feet. The grainers will measure 140x12x2½ feet, four or five being used. These will be equipped with self-rakes.

The grainers and settlers are all lined with two inch layers of sandstone obtained from the Rarden quarries near Portsmouth. Cotton is used for packing the joints in the settlers and grainers.

Calcium and bromine plants will be operated. It is expected that the plant will make 200 barrels of salt per day, beginning in January, 1906.

The Manufacture of Bromine.—After the salt has been removed from the grainers, the remaining liquid known as bittern and having a density of from 35° to 40° B., is run into a tank where it settles. It is then conducted to a still, the body of which is made of sandstone.

The bittern and chemicals are poured into the still through a funnel-shaped opening in the top, and withdrawn from the still by a small opening in the bottom, after the bromine has been removed. Steam is blown into the still by a small opening in the bottom, producing a temperature reported at about 180° F.

The condenser is simply a rectangular box about five feet long, through which pass three lead pipes extending from the still at one end to the bottle which collects the bromine at the other. Cold water is kept running through the box, condensing the bromine.

The bromine exists in the bittern as magnesium bromide ($MgBr_2$), comprising about one-half of one per cent. of the mass.[1] After bittern has been run into the still and steam turned in, sulphuric acid (H_2SO_4) is added, the proportion being one pound of the latter to twenty gallons of the former. This is followed by the addition of potassium chlorate ($KClO_3$), the ratio being one pound to sixty gallons of bittern.

The following reaction takes place in the still:

$$3MgBr_2 + KClO_3 + 3H_2SO_4 = 6Br + KCl + 3MgSO_4 + 3H_2O.$$

The bromine escapes as a gas, but is changed to a liquid in the condenser.

Formerly manganese dioxide (MnO_2) was used in place of the potassium chlorate, the change resulting from the lower cost of the latter.

The Manufacture of Calcium Chloride.—After the bromine has been removed the liquid is conveyed from the still to a large cistern where it is treated with lime. This neutralizes any acid that may remain and helps to clarify the liquid. It is then condensed by boiling in an open pan. The process is completed in kettles containing steam coils, the calcium chloride remaining as a thick liquid which solidifies on cooling. In this condition it is shipped to many parts of the world.

Fuel.—The fuel used in all of these plants is coal. The Pittsburg, or, as it is locally known, Pomeroy coal, lies near the foot of the hills immediately back of the town, and serves admirably for the production of the necessary heat. In fact, were it not for this natural advantage the salt and dependent industries in Pomeroy and vicinity would have disappeared a decade ago. In some cases the companies have mined their coal, in others it has been purchased from a neighboring mine. Originally the poorest part of the seam and the slack appear to have been used in the furnaces and this is true to some extent at the present time. More generally, however, run of mine coal is now used.

---

[1] *Geol. Sur. of Ohio,* vol. VI, p. 663.

All report that one bushel of coal will evaporate enough brine to yield a bushel of salt. Some claim that one bushel of this fuel will produce one and one quarter bushels of salt. This ratio depends largely on whether run of mine or the poorer parts of the coal are used.

Geological Considerations.—The surface rocks in the valley at Pomeroy lie at the summit of the Conemaugh formation, formerly known as the Lower Barren Coal Measures.[1]

The depth of the wells has undergone great variation. At first they were shallow, reported at about 300 feet. This reached the horizon of the first Cow Run sand, an important source of petroleum in Washington and Morgan counties. Later the wells were extended until a larger supply of brine was secured. When these proved inadequate, the wells were again deepened.

The following skeleton record of a well belonging to the Buckeye Salt Company is interesting in this connection. The well head is 25 feet below the Pomeroy or No. 8 coal.

Conductor	58 feet.
Shale	58– 550 feet.
White and gray sand	550– 870 feet.
White sand and slate	870– 960 feet.
Big Salt sand	960–1130 feet.
Sand and white shale	1130–1495 feet.
Berea grit	1545–1570 feet.
Total depth	1590 feet.

Brines were reported as follows:

Depth in feet.	Density.
320	6° B.
710	9° B.
980	9° B.
1550	16° B.

It is seen that the brine found in the Berea is much denser than that found in overlying rocks. The quantity, however, was small, and the well is pumped from the horizon of the "Big Salt sand." This company has five wells, the depths varying from 1,089 to 1,590 feet, the latter penetrating the Berea. The Excelsior Company has four wells whose depths range from 1,100 to 1,200. Wells drilled farther east are deeper, since the rocks dip in that direction.

---

[1] *Geol. Sur. of Ohio*, Fourth Series, Bull. No. 7, p. 4.

When drilling first began in this territory, the water is said to have risen nearly to the well heads, and in some cases actually overflowed. As pumping progressed the reservoirs of brine were lowered, and at the same time the tubing was extended deeper into the wells. In this manner the tubing followed the brine in its descent.

For many years the Excelsior works have pumped from the 750 foot level. The brine is said to rise slightly when the wells in the neighboring plant are not in action.

The density of the brine increases in the direction of the dip of the rocks; that is, to the southeast.

This is shown by the following data:

	Density of brine.	Temperature of brine.
Pomeroy Salt Works, west end of Pomeroy	8° B.	61½° F.
Koehler's Excelsior Salt Works, east end of Pomeroy	8½° B.	63° F.
Syracuse Salt, Bromine and Calcium Works	10½° B.	62½° F.

The variation in density is due to the heavier brines seeking the lower level. The variations in temperature result in part from the different conditions under which the measurements were made; it not being possible in all cases to ascertain the temperature directly at the well head. The variation is due also in part to the greater depth of the wells to the southeast.

The quantity of brine that has been taken from these rocks is enormous, much more than the rocks could at any one time contain. This great excess has doubtless been derived from surrounding territory. The brine bearing strata dip towards Pomeroy from the northwest. As the brine has been pumped from the wells, the supply has been renewed from the rocks lying at a higher level.

Doubtless the brine was once a part of the ocean. As the sand or gravel, now composing the salt bearing rocks, was deposited on the ocean floor, sea water filled the spaces between the grains and pebbles and has since remained in that position.

The composition of sea water, according to Dittmar, is as follows:

$NaCl$	77.758
$MgCl$	10.878
$MgSO_4$	4.737
$CaSO_4$	3.600
K_2SO_4	2.465
$MgBr_2$	0.217
$CaCO_3$	0.345

Comparing this analysis with that of the brine given on the following page shows points both of resemblance and difference. It must be borne in mind, however, that the Pomeroy brines were from near the shore, perhaps from a land locked sea, and hence might vary considerably from those of the open ocean. This fact explains the presence of the relatively large amounts of bromides and iodides, since these substances are contained in certain marine plants. Probably conditions were very favorable for these plants in the early sea in the vicinity of Pomeroy.

Chemical Examination.--This was made by Professor C. W. Foulk of the State University, and unless otherwise stated all work of this nature is to be credited to him.[1] An analysis of salt obtained in 1905 from Coal Ridge Salt Works, Pomeroy, gave the following results:

Moisture	7.42
Sodium chloride	91.31
Sodium sulphate	0.00
Calcium chloride	0.95
Magnesium chloride	0.32
Silica, iron and aluminum oxide	0.00

A sample of brine from the wells of the same company was also examined. This brine evidently contains most if not all of its iron in the ferrous condition since the characteristic precipitate forms on standing. Following are the results of the analysis:

	Grams per liter of brine.	Grains per U. S. gallon of brine.
Silica	0.012	0.70
Iron and aluminum oxides	0.083	4.81
Calcium chloride	14.340	831.72
Magnesium chloride	5.590	324.22
Magnesium bromide	0.155	8.99
Strontium chloride	0.257	14.91
Barium chloride	0.343	19.89
Sodium chloride	84.300	4889.40
Sodium iodide	0.004	0.23
Sodium sulphate	0.000	0.00
Potassium chloride	0.114	6.61
Lithium	Trace	Trace
Specific gravity	1.075	

If the rather large numbers above for the content of sodium chloride be recalculated in more familiar units the strength of the brine is found to be 0.70 pound salt per gallon.

An analysis of the Pomeroy brine was made in 1888 by Root,[2] who apparently calculated the results as percentages of the sum of the constituents found. A comparison of the two analyses made at such widely different times is of interest, and accordingly in the following table Root's results of 1888 are given together with the present analysis which has been recalculated as percentages of the total.

	Analysis of 1906.	Analysis of 1888.
Specific gravity	1.075	1.071
Sodium chloride	80.134	79.273
Calcium chloride	13.633	14.397
Magnesium chloride	5.314	6.097
Magnesium bromide	0.147	0.097
Sodium iodide	0.004	0.012
Silica	0.079	0.043
Iron and aluminum oxides	0.011	0.082
Potassium chloride	0.108	.....
Strontium chloride	0.244	.....
Barium chloride	0.326	.....

---

[1] *Geol. Sur. of Ohio*, vol. VI, p. 663.

[2] For a brief description of the methods employed, see appendix.

The absence of sulphates from the southern Ohio brines has been noted as remarkable, distinguishing them from others. This is now easily explained in light of the barium salt which they carry. Any sulphates would long since have been precipitated.

V. NORTHEASTERN OHIO.

The salt industry in northeastern Ohio is of recent origin, but the development has been such that the quantity of salt produced greatly exceeds that in the southeastern part of the state. In fact were it not for the territory now under consideration Ohio would not rank as an important salt producer.

The industry began at Newberg about 1889, and has extended to Cleveland, Kenmore (near Akron), Wadsworth and Rittman. The growth has been rapid and seems capable of almost indefinite expansion.

The Wadsworth Salt Company.—This plant is the result of drilling for oil. About the year 1886 an experienced oil driller from Pennsylvania chanced to pass through Wadsworth on the Erie railroad. Just west of the village he noticed, as he rode by, a rock exposure which he thought indicated deposits of oil below. After reaching his home he took up the matter by correspondence with the postmaster at Wadsworth. Later he came to the village, and raised by popular subscription sufficient funds to drill a well. Before the test was begun 15,000 acres of land were leased.

The driller expected to find oil at a depth similar to that at Washington, Pennsylvania. Work was begun about 1889 and progressed slowly, so that more than a year elapsed before the depth of 3,200 feet was reached. The only fuel found was a small flow of gas, but at a depth between 2,400 and 2,500 feet rock-salt was penetrated. The well was abandoned.

The disclosure of the drill naturally started discussion among citizens of the community and others interested in the salt industry. This resulted in 1891 in the organization of a salt company. Two years later the organization was incorporated, the capital stock being $100,000.

The company secures its brine from two wells; the first was completed early in 1892, and is 2,707 feet deep, the second was finished in 1898, being 2,685 feet deep. No logs of these wells were secured, but the manager of the company, Mr. F. W. Boyer, reports that four beds of rock-salt having an aggregate thickness of 140 feet were found, and below these a honeycomb limestone 100 feet in thickness containing salt in the cavities. The manager states that salt is taken from the higher two beds only.

The rock-salt is dissolved by water which is supplied by wells, 18 in number, and about 100 feet in depth. A continuous stream of fresh

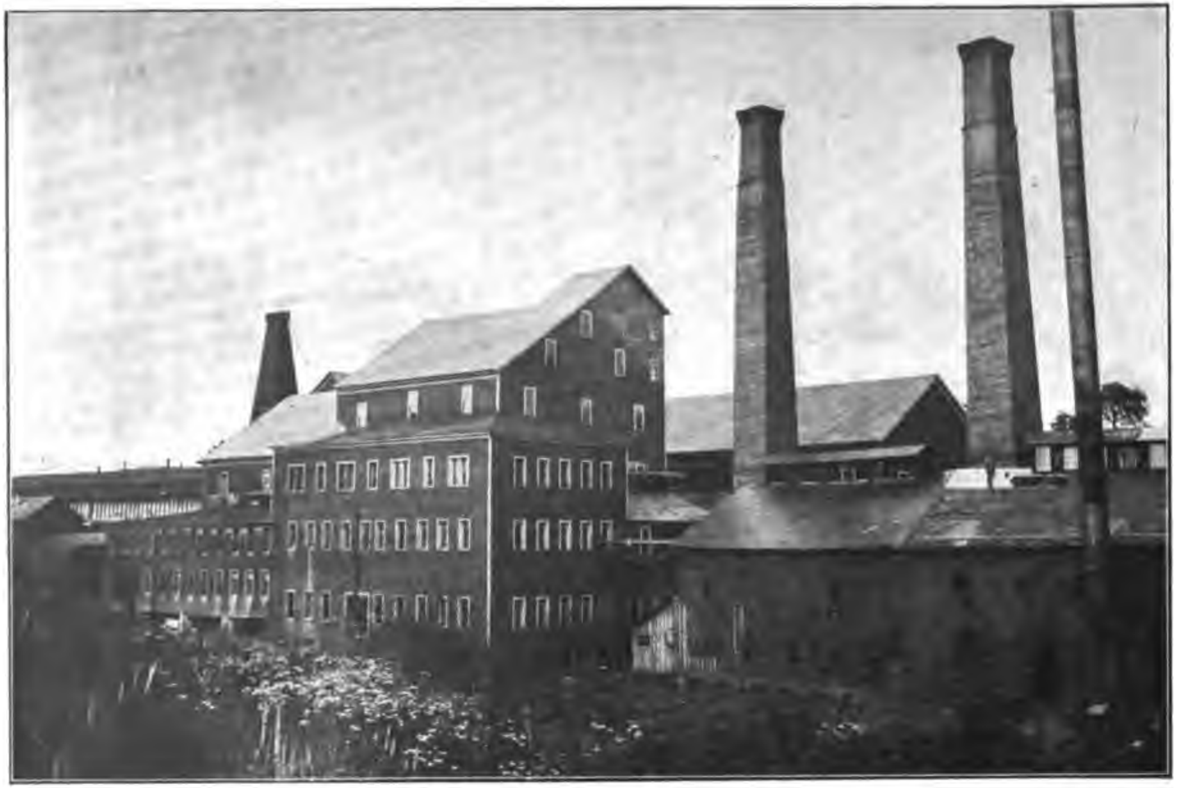

Figure 5.—Exterior view of a modern salt works at Wadsworth.

water is run into the wells. The salt beds uniting the two wells have been dissolved in places, and in consequence the two are connected by a subterranean channel.

From the wells the brine, saturated or nearly so, is forced into a large reservoir from which it is run into the vacuum pans.

The Vacuum Pans.—The company uses the vacuum process entirely. Two vacuum pans are used, each forty feet high and ten feet in diameter. Each pan contains 800 evaporating tubes, two and one-half inches in diameter and about four feet in length. In the center of this group of tubes is a large one, twenty-four inches in diameter and about six feet in length.

Heat in the pans is supplied by steam of three grades, (1) exhaust; (2) low pressure, from thirty-five to forty pounds; and (3) high pressure, from 125 to 140 pounds to the square inch. The object of using varying temperatures is to obtain salt having the desired grain. As has already been stated, the more rapid the evaporation the finer the salt. A temperature of approximately 135° F. is most commonly maintained in the pans.

The vacuum in the pans is usually twenty-five inches, and is maintained by an air pump and by the condensation of steam produced by the evaporation of the brine.

Drying, Screening and Marketing.—The salt is removed from the evaporators by buckets attached to endless chains and deposited in wooden bins where it dries from two to four hours. From this place the salt is removed in hand carts to the warehouse where it dries from thirty to ninety days, depending chiefly on the demand for salt.

Sometimes a small quantity of salt is taken directly from the warehouse and marketed. By far the greater quantity, however, is removed in hand carts to the drying department.

The driers consist of revolving metal kilns, thirty-four feet in length and six feet in diameter. The kilns lie nearly horizontal, one end being slightly elevated so that on rotating the salt will slowly creep from the higher end to the lower. Heat in the kilns is maintained by steam, and the drying is further promoted by hot air blown through the kilns. About twenty-five minutes are required for salt to pass through the drier.

After having been dried the salt is carried to the top floor where it is screened and then conveyed to the storage bins. From these the salt is packed and marketed. The refuse material resulting from screening is sold for making ice cream and other purposes not requiring a pure salt.

The plant has a capacity of 1,200 barrels of salt per day, and furnishes employment when working in full for 150 people, men, women and boys.

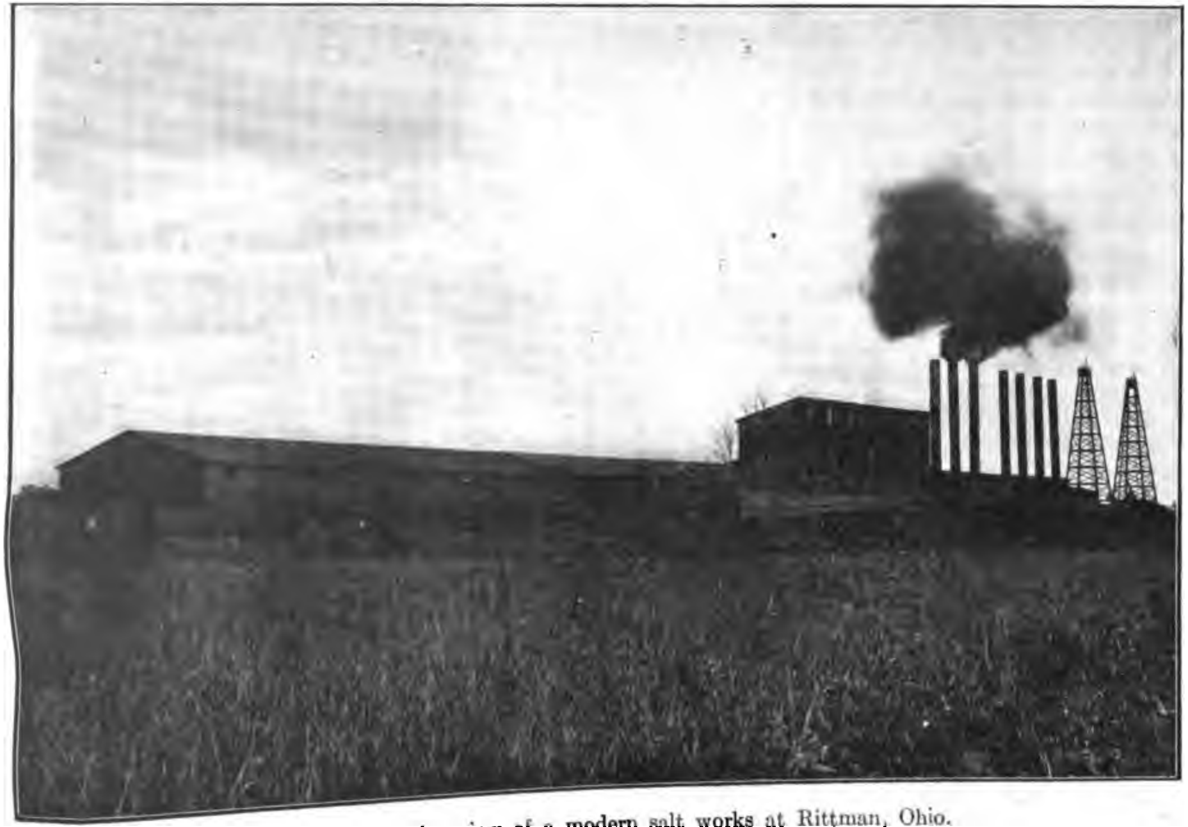

Figure 6.—Exterior view of a modern salt works at Rittman, Ohio.

Ohio Salt Company.—This plant is located at Rittman in the northeast corner of Wayne county. The company was incorporated in March, 1898, with a capital stock of $250,000. The first salt was made in the autumn of that year, and for the ensuing twelve months the average daily production was 600 barrels. From time to time the capacity of the plant has been increased. In July, 1903, it was 1,500 barrels, and in May, 1905, 2,000 barrels.

The company has four wells each approximating 2,625 feet in depth. Two of these are only 100 feet apart, but the other two are 600 feet from each other and from the first two. A skeleton record of two of these wells is given below:

WELL NO. 1.

		Feet.
Clay		40
Quicksand and gravel		133
Gray sandstone (Berea)		20
Bedford and Ohio shales	Black shale	1007
	Red shale	50
	Slate and shells	250
	Brown shale	535
Corniferous and Monroe formations	Limestone	268
	Gray sandstone	30
	Shelly limestones	225
Salina formation	Rock-salt	66
	Total	2624

WELL NO. 3.

		Feet.
Drift		171
Cased out fresh water at		240
Struck mineral water at		2272
Cased this out at		2324
Salina formation	Rock-salt at 2513 feet	6
	Limestone	25
	Rock-salt	30
	Limestone	5
	Rock-salt	35
	White slate	30
	Limestone	7
	Total depth	2651

Fresh water is pumped into the wells, and brine saturated or nearly so lifted from them. The wells only 100 feet apart have already had sufficient salt removed between them to form an underground connection between the two. One of the more distant wells has in a similar way been connected with the first two.

Salt Manufacture.—The company uses both the vacuum pans and grainers. Of the former there are two; one has 1,004 tubes each four feet in length and two and one-half inches in diameter, and a central tube four feet in length and two and one-half feet in diameter. The other pan has 840 tubes each four feet nine inches in length and two and one-half inches in diameter, and a central tube four feet in length.

Only one pan is operated at a time, each being used twenty-four hours and then lying idle for an equal time. After having been used the pans are washed with cold fresh water to remove any salt that may have been deposited in them during the preceding day. Gypsum is slowly deposited in the tubes, and has to be removed from them by boring once in two months. Formerly this operation had to be made every twelve hours. It is claimed that the rate of deposition of gypsum depends very largely on the methods followed in evaporating the brine.

The temperature in the pans is reported to be approximately 120° F., and the vacuum from twenty-seven to twenty-eight inches. The temperature just referred to is maintained both by exhaust and live steam.

After leaving the pans the salt passes through substantially the same processes as those already described at Wadsworth. Part of the salt is marketed before drying. This is shipped in bags and barrels. Some, however, is shipped in bulk in box cars. The dried salt is packed in bags in sizes weighing from one to 224 pounds. The small bags weighing from one to five pounds are filled by machinery. The latter is operated by girls, an average day's work for one girl being 5,000 bags of three pounds each. For the smaller amounts a patent bag which does not require sewing after filling is used. The bags weighing from eight pounds and above, when filled, are sewed by hand.

This salt is used principally for table and dairy purposes. Any dirty salt finds a market for glazing, fertilizing, ice cream manufacture, etc.

The Grainers.—There are seven of these. Two measure each 160x10x2 feet. These are provided with self-rakes, consisting of two endless iron chains, one on each side of the grainer, to which are attached transverse flat strips of iron. The latter draw the salt out of the grainer as fast as it accumulates on the bottom. This is a distinct improvement over the old method of removing the salt with hand shovels.

Salt making in these grainers is a continuous process. Brine runs into them day and night, and salt is raked out as fast as formed. Each grainer makes 150 barrels of salt per day.

Five grainers measure each 160x12x2 feet. These are not provided with self-rakes, the salt being removed by shovels with hand labor.

Located about 300 feet from the plant under consideration are the works of the Ohio Box Board Company. This company obtains its electrical power from the salt works and furnishes the latter with exhaust steam. This is used in the vacuum pans and to a smaller extent in the grainers. Some live steam also is used.

Grainer salt commands a higher price than the vacuum, the difference amounting to about ten cents per barrel.

The company reports that it uses neither alum, lime, soda, nor anything else in the brine.

Fuel.—The company owns and operates its own mines. These are located some miles distant, but nevertheless furnish the necessary fuel at the lowest expense.

Market for Salt.—No traveling salesmen are employed. Among the heavy consumers may be mentioned H. J. Heinz and Company and The National Biscuit Company. Large quantities are shipped to various parts of the United States and Canada. Dirty salt is sold for fertilizing, glazing, melting ice on car tracks, etc.

The Union Salt Company.—This company succeeded the United Salt Company, which controlled the pioneer plants in northeastern Ohio. These were first, in point of time, the plant at Newberg. This was a direct result of drilling for gas for a Cleveland rolling mill. The sand pump brought glassy particles that proved to be rock-salt, and the construction of the furnace was soon begun.

On account of the unusual interest of this pioneer record, the drillers' log, as interpreted by Dr. Edward Orton, is given below:[1]

		Thickness of formation feet.	Total depth feet.
Drift		40	40
Ohio and Bedford shales		1310	1350
Corniferous and Monroe formations	Limestone	310	1660
	Sand containing lime	40	1700
	Limestone	290	1990
Salina formation	Rock-salt and shale	164	2154
	Shale	15	2169
	Limestone	81	2250
	Rock-salt	50	2300
	Shale, blue	40	2340
	Sand	20	2360
	Shale	18	2378
	Limestone	22	2400
	Rock-salt	20	2420
	Shale	10	2430
	Limestone	40	2470
	Rock-salt	5	2475
	Shale	8	2483
Niagara formation	Limestone	167	2650
	Oil sand	8	2658
	Limestone	22	2680
	Oil sand	6	2686
Clinton formation	Limestone	64	2750

Later, drilling was continued through "limestones of the same general character" to a depth approximating 3,000 feet, when the tools became fast and work of necessity ceased.

---

[1] *Geol. Sur. of Ohio*, vol. VI, p. 352.

Chemical analyses have been made from drillings taken at several horizons. These show that the shales associated with the rock-salt consist largely of calcium sulphate, and that the top of the Niagara is strongly magnesian and the lower part almost a pure dolomite.

The grainer process alone was used in making salt. The plant ceased work in the fall of 1902 and was dismantled in 1905. Its capacity was 700 barrels per day.

The only plant of this company in operation in 1905 was the one located on the lake front at the foot of Madison street. This began making salt about 1890. The brine is supplied by five wells having depths approximating 2,000 feet.

Following is the log of well No. 4, drilled in 1893:

Drift	Sand	15 ft.	267 ft.
	Quicksand	6	
	Blue clay	129	
	Sand and clay	9	
	Quicksand	76	
	Sand and gravel	6	
	Gravel and clay	26	
	316 ft. of 10-in. casing.		
Shales (Ohio)		723	723
	379 ft. of 8¼-in. casing.		
Corniferous, Monroe and Niagara formations	Limestone	390	775
	White sandstone	33	
	Limestone	11	
	White sandstone	16	
	Limestone	315	
	Limestone and rock-salt	10	
Salina formation	Rock-salt	16	229
	Limestone	16	
	Rock-salt	19	
	Limestone	4	
	Rock-salt	59	
	Limestone	21	
	Rock-salt	37	
	Limestone	4	
	Rock-salt	37	
	Slate	16	
	Total depth (steel line meas.)		2006½ft.

A "heavy" flow of gas was reported at 150 feet; water at 159 and 235 feet, and a "light" flow of gas at 242 and 306 feet.

Both live and exhaust steam is used in the vacuum pans. In some grainers live steam is used, in others exhaust steam. The fuel is partly run of mine and partly slack coal.

The company manufactures the barrels and bags used in marketing the salt.

When the plant is running in full it produces about 1,800 barrels of salt per day.

The third plant of the Union Salt Company is located at the foot of Marquette street. Thus far (1905) it has never been in successful operation.

An effort has been made here to introduce an entirely new method in salt manufacture in Ohio. The plan consisted essentially of heating the brine and then forcing it into a spray. Through the latter hot air was forced. This was expected to carry away the water, the salt collecting below. The plan was unsuccessful.

The company expects to remodel this plant and start it in operation in the near future. While the proposed plan is new to Ohio it is not new to the country, being reported to have been successfully tried in Michigan.

The brine will be heated to a temperature of about 230° F. and then run into grainers. It will move slowly in these from one end to the other depositing salt all the while. Since the brine in the higher end of the grainer is hottest, it will deposit the finest grained salt. The salt will gradually become coarser toward the lower end of the grainer.

The brine in the grainers from which the salt is not deposited will be conveyed to other grainers for making coarser salt or forced back to the heaters and then returned again to the grainers as before.

In this work two larger grainers, each about 80x40x2 feet, will be used. These, however, will be connected with others for making coarser salt.

All will be equipped with self-rakes for removing the salt.

The points claimed for this system, which has just been outlined, are:

1. It will be automatic and continuous.
2. It will largely reduce the labor.
3. It will abolish the present necessity of piping the grainers.
4. It will require less fuel.

The company's market extends from the Atlantic to the Mississippi river, and as far south as Alabama.

The Cleveland Salt Company.—This company was organized in 1897, and began making salt in 1900. The plant is located at the corner of Second and Central avenues.

Brine is supplied by three wells, each approximating 1,950 feet in depth. The following skeleton record of well No. 2 shows the position and thickness of the salt beds:

Shales and limestone	1821 ft.
Rock-salt	10
Limestone	5
Rock-salt	5
Limestone	5
Rock-salt	10
Limestone	22
Rock-salt	72
Limestone	2
Total depth	1952 ft.

The company uses the vacuum and grainer methods in making the salt. The two vacuum pans each measure fifteen feet in diameter, and each has a capacity of 150 tons of salt per day. A temperature of 125° F. is reported in the pans, and a vacuum of twenty-five or twenty-six inches. As elsewhere gypsum causes trouble. It accumulates in the tubes of the pans and has to be bored out every other day.

Three of the four grainers are equipped with self-rakes. The fourth is used to make a coarse salt, and has a capacity of about five and one-half tons per day.

The brines in the pans and grainers are heated by exhaust steam obtained from the Cleveland Electric Railway Company and from the company's own boilers. It is claimed that this is much less expensive than using live steam entirely. The brines are not treated with chemicals of any kind.

That part of the grainer salt prepared for domestic use is screened and dried, the methods being similar to those already described.

The company employs from forty to sixty people. It does not manufacture the barrels used.

The company's market extends from the Atlantic to the Mississippi river, and as far south as Alabama.

The capacity of the plant is given at 90,000 tons of salt per year.

The Colonial Salt Company.—This company was incorporated under the laws of New Jersey in February, 1901, with paid-up capital of $350,000.

The works are located at Kenmore, between Akron and Barberton, in Summit county. The writer was not permitted to enter the works, and hence this report is not as complete as it would otherwise have been.

Brine is supplied by six wells, having a depth approximating 2,800 feet. Below is a log of one of these:

Drift	115 ft.
(Water at 110 feet).	
Slate and shells	1943
Limestone	694
(Water at 2398 and 2465 feet).	
Salt	7
Limestone	4
Salt	37
Limestone	22
Salt	30
Limestone	4
Total depth	2856 ft.

The rock-salt is dissolved by water from wells 150 feet in depth. In the evaporation of the brine both vacuum pans and grainers are used. No attempt is made to precipitate the gypsum which the brine contains.

The two vacuum pans are said to measure seventeen feet in diameter and to have 2,000 tubes. The heat used is by the double effect method. Live steam is used in the first pan, and the steam formed in this pan is conducted to the second one. A vacuum of fifteen inches is used in the first and from twenty-five to twenty-eight inches in the second pan.

Fourteen grainers are used. Eight are supplied with self-rakes, and in the remaining ones the salt is removed with shovels by hand. Evaporation in the eight just referred to is produced by live steam, and the latter, having passed through these grainers, is conducted to the remaining six, supplying heat to them. It follows that the last grainers referred to produce coarser salt than those supplied with live steam.

The company claims to produce by all methods about 400 tons of salt per day. The salt finds a market in the Central States, New England, South, and to some extent in the far West.

Chemical Examination.—A sample of brine from the wells of the Union Salt Company, Cleveland, gave the following results:

	Grams per liter of brine.	Grains per U. S. gallon of brine.
Silica	0.000	0.00
Iron and aluminum oxides	0.000	0.00
Calcium chloride	1.033	60.28
Calcium sulphate	4.857	283.40
Magnesium chloride	0.462	26.80
Strontium chloride	0.089	5.16
Barium chloride	0.000	0.00
Sodium chloride	310.977	18161.00
Potassium chloride	0.713	41.35
Sodium iodide	0.000	0.00
Magnesium bromide	0.012	0.70
Lithium salts	Trace	Trace
Specific gravity	1.204	

Recalculated in more familiar units, the brine was found to contain 2.59 pounds of salt per gallon. That at Pomeroy, as already stated, has only 0.70 pound of salt per gallon.

The following analyses show the composition of the salt made in northeastern Ohio. The samples tested were all made by the vacuum pan process, except No. 5 which is a grainer salt.

1. "Chippewa Salt," Ohio Salt Co., Rittman.
2. "Standard Granocrystal," Wadsworth Salt Co., Wadsworth.
3. "Buckeye," Union Salt Co., Cleveland.
4. "Quality and Quantity," Union Salt Co., Cleveland.
5. "No. 1 Common Fine," Union Salt Co., Cleveland.

Number.	1	2	3	4	5
Moisture	0.52	0.57	0.37	0.39	1.22
Sodium chloride	98.09	97.61	98.81	98.33	97.91
Calcium sulphate	1.19	1.70	0.68	1.02	0.68
Calcium chloride	0.20	0.12	0.14	0.26	0.08
Magnesium chloride	0.00	0.00	0.00	0.00	0.07
Silica, iron and aluminum oxides	0.00	0.00	0.00	0.00	0.04

Limits of the Field.—The salt producing area in northeastern Ohio is large, but not unlimited in extent. Thus far the furnaces are restricted to four counties—Cuyahoga, Summit, Medina and Wayne. However, the salt deposits are not limited to this territory. That the beds in question extend farther east is shown by the following record of the Hadsell well near Cortland, in the eastern part of Trumbull county:

			Depth of formation feet.	Total depth feet.
Drift			40	40
Shale			60	100
Berea grit			160	260
Bedford and Ohio shales			2396	2656
Corniferous and Monroe limestones			583	3239
Salina formation	Rock-salt	12 ft.	471	3710
	Limestone	5		
	Rock-salt	2		
	Limestone	3		
	Rock-salt	10		
	Limestone	49		
	Rock-salt	29		
	Limestone	10		
	Rock-salt	52		
	White shale	18		
	Limestone	36		
	Rock-salt	10		
	Limestone	50		
	White shale	15		
	Rock-salt	30		
	Limestone	10		
	Rock-salt	3		
	White shale	90		
	Limestone	5		
	Blue shale	32		
	Total depth			3710

It may be noted that this record shows 148 feet of rock-salt. If the alternating strata of limestone are similar to those farther west in having many large holes filled with salt, then the total quantity is much in excess of the 148 feet. The record shows that the salt strata extend to the eastern limits of the state.

To the south the limit of the salt deposits has not been determined. This follows from the fact that the strata dip to the south and east, and hence the salt horizon lies so deep that it has not been reached by the drill.

Westward the limit has not been determined. It cannot extend as far as Sandusky, however, as the following record shows:[1]

Drift	10 ft.
Corniferous limestone	100
Monroe and Niagara limestone	970
Niagara shale and Clinton formation	105
Medina shale	175
Cincinnati shale and limestone	500
Utica shale	310
Trenton limestone at	2210

---

[1] *Geol. Sur. of Ohio*, vol. VI, p. 195.

The Monroe and Niagara limestones were found to contain numerous layers of gypsum, fourteen having been noted, but none of salt.

However, considering the area beneath which salt has been demonstrated to exist and the number and thickness of the beds in question warrants the conclusion that northeastern Ohio contains enough salt to supply the entire country for an indefinite period.

UNIV. OF
CALIFORNIA

APPENDIX

METHODS OF ANALYSIS

Salts.—From two to three grams were subjected to the conventional methods for the determination of silica, oxides of iron and aluminum, calcium and magnesium salts. The sulphates were precipitated from five gram samples. For the estimation of moisture three grams were ignited to constant weight at a dull red heat, the loss in weight being called the moisture. Sodium chloride was determined by difference.

Brines.—Silica and iron and aluminum oxides were determined in 100 cubic centimeter samples. For calcium and magnesium salts fifty cubic centimeters were used, the results being corrected for strontium and barium. Sodium was determined in a ten cubic centimeter sample of the Pomeroy brine and in four cubic centimeters of the one from Cleveland. Accuracy of measurement of these small amounts was insured by diluting a larger portion and taking an aliquot part. Sulphates were precipitated from 250 cubic centimeters of the Cleveland brine. For strontium from fifty to 100 cubic centimeters were used, the strontium and calcium being twice precipitated as oxalate, and after transformation into nitrates subjected to the ether-alcohol separation. The residues of strontium showed neither calcium nor barium on examination with the spectroscope. Potassium was estimated in 100 cubic centimeter samples after precipitating the sodium chloride with hydrochloric acid gas. This was readily accomplished in a glass-stoppered washing bottle. A blank was tried to determine whether the acid attacked the glass and gave negative results. The filtrates from the potassium platinic chloride were examined with the spectroscope for lithium. Both brines showed traces, the Cleveland brine seeming to have more than the one from Pomeroy. Barium was determined by precipitating from 500 cubic centimeters with sulphuric acid. The resulting precipitate was fused with sodium carbonate, extracted with water and the barium precipitated as chromate from the acetic acid solution of the carbonates.

For bromides and iodides 500 cubic centimeters were treated with an excess of sodium carbonate, boiled and filtered. The filtrate was evaporated, the salt separating being filtered off from time to time and washed with alcohol. In this way the amount of salt was reduced to a few grams when the final residue was gently ignited and the resulting black mass boiled with water and filtered. This was diluted to about 200 cubic centimeters, placed in a flask together with two cubic centimeters of sulphuric acid and ten cubic centimeters of a ten per cent. solution of sodium nitrite and distilled with steam, the iodine evolved being received in an ammoniacal solution of hydrazine sulphate from which it was precipitated with silver nitrate after acidifying with nitric acid. The residual liquid in the flask was made alkaline with caustic soda and concentrated to about 50 cubic centimeters, when it was made just acid with sulphuric acid and returned to the distilling flask where it was distilled with steam after adding 1.5 grams of potassium permanganate and ten cubic centimeters of strong acetic acid. The bromine evolved was collected and determined as for iodine.

Repeated trials with the brines and with artificial brines made from salt and Columbus city water and containing known amounts of iodides and bromides showed that the above methods failed completely in the presence of a large excess of sodium chloride. Chlorine invariably distilled over, sometimes in large amounts and small amounts of iodine were held back. When, however, the bulk of the salt was removed the method worked satisfactorily. Distillation with ferric chloride was also tried and this too failed to show any iodine in the Pomeroy brine.

In the Cleveland brine iodine was not recognized with certainty, though it is possible that by taking a larger portion for the analysis it could be found.

In conclusion it might be stated that substances not given in the tabulated analyses were not looked for.

14 DAY USE
RETURN TO DESK FROM WHICH BORROWED

EARTH SCIENCES LIBRARY

This book is due on the last date stamped below, or
on the date to which renewed.
Renewed books are subject to immediate recall.

AUG 3 1971

JUL 6 - 1976

LD 21-40m-5,'65
(F4308s10)476

General Library
University of California
Berkeley

-185

U.C. BERKELEY LIBRARIES

C033558754